

Message

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Subject: RE: Guam Minor Source Baseline date
Attachments: GPA Modeling Protocol v1.0.pdf

Hi Laura/everyone –

That seems consistent with what Trinity Consultants listed as the minor source baseline date for Guam from their modeling protocol in 2018. I attached the full protocol if you want to take a look, but below is a screen shot of the relevant table. I'm not sure if other previous modeling exercises indicated something else, but perhaps Carol or Scott may know of others?

Table 3-4. PSD Baseline and Trigger Dates for Guam

Pollutant	Averaging Periods	Minor Source Baseline Date	Major Source Baseline Date	Trigger Date
NO _x	Annual	1992 ^A	February 8, 1988	February 8, 1988
PM ₁₀	24-hour and Annual	1992 ^A	January 6, 1975	August 7, 1977
PM _{2.5}	24-hour and Annual	2018 ^B	October 20, 2010	October 28, 2011

^A PSD CII 92-01 for the Dededo Generating Station, issued April 16, 1993.

^B This application will be the first PSD application after the PM_{2.5} major source baseline date.

Khoi

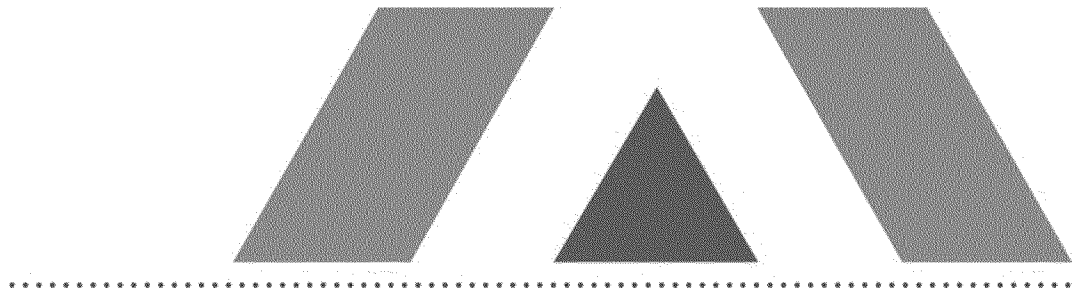
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Sent: Friday, July 10, 2020 8:19 AM
To: Bohnenkamp, Carol <Bohnenkamp.Carol@epa.gov>; Bohning, Scott <Bohning.Scott@epa.gov>
Cc: Nguyen, Thien Khoi <nguyen.thien@epa.gov>
Subject: Guam Minor Source Baseline date

Hi everyone,

I'm wondering if in any previous modeling done for Guam there would be any notes/statement of what the minor source baseline date is for Guam? I've looked at the earliest PSD permit I can find that EPA issued in 1993 and have a Aug. 1, 1992 date as the application complete date. So this is what I believe the minor source baseline date is, but I wanted to check in with you guys to see if we've said it was something else in previous modeling exercises. Please let me know if you have any information on this.

Thanks!

Laura



PREVENTION OF SIGNIFICANT DETERIORATION MODELING PROTOCOL

Proposed New Reciprocating IC Engine Power Plant
Adjacent to Harmon Substation, Guam

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TABLE OF CONTENTS

1. INTRODUCTION	1-1
2. APPLICABILITY OF PREVENTION OF SIGNIFICANT DETERIORATION	2-1
3. AMBIENT IMPACT AND PSD CLASS II INCREMENT MODELING INPUTS	3-1
3.1. Model Selection	3-1
3.2. Project and Existing Emissions	3-2
3.2.1. Project Emissions	3-2
3.2.2. Nearby Sources	3-5
3.3. AERMOD Meteorological Data	3-6
3.4. AERMOD Receptor Data And Modeling Domain	3-11
3.5. Background Concentrations	3-12
3.6. GEP Stack Height and Building Downwash	3-14
3.7. Urban/Rural Classification	3-14
4. AMBIENT IMPACT AND PSD CLASS II INCREMENT MODELING METHODOLOGY	4-1
4.1. Project Impact Analysis	4-1
4.2. PM _{2.5} Impacts	4-3
4.2.1. Preconstruction PM _{2.5} Monitoring Requirements	4-3
4.2.2. PM _{2.5} Ambient Air Quality Analysis	4-3
4.3. Cumulative Impact Analysis	4-4
4.3.1. Ambient Air Quality Modeling Analysis	4-5
4.3.2. PSD Class II Increment Analysis	4-5
4.4. Ozone Analysis	4-5
4.4.1. Preconstruction Ozone Monitoring Requirements	4-6
4.4.2. Ozone Ambient Air Quality Analysis	4-6
5. PSD CLASS I AREA ANALYSIS	5-1
6. ADDITIONAL IMPACT ANALYSIS	6-1
6.1. Class II Visibility	6-1
6.2. Growth	6-1
6.3. Vegetation and Soils Impacts	6-1
6.4. Environmental Justice	6-4
6.5. Additional Federal Requirements	6-4
6.5.1. Coastal Zone Management Act	6-4
6.5.2. National Historic Preservation Act	6-4
6.5.3. Magnuson-Stevens Fishery Conservation and Management Act	6-5
6.5.4. Endangered Species Act	6-5
7. REFERENCES	7-1
APPENDIX A : EMISSION CALCULATIONS	A-1
APPENDIX B : NO ₂ MODELING TIER 3 JUSTIFICATION	B-1

LIST OF FIGURES

Figure 1-1. Proposed Project Location 1-1

Figure 3-1. Project Site and GUM Locations 3-8

Figure 3-2. GUM Wind Rose (2012-2016)..... 3-9

Figure 3-3. Initial Receptor Grid..... 3-12

Figure 3-4. Area Surrounding the Project Site (3-km Radius) 3-16

LIST OF TABLES

Table 2-1. Preliminary Project Emissions.....2-2

Table 3-1. Preliminary Stack Locations.....3-4

Table 3-2. Preliminary Wärtzilä 18V50DF Modeled Stack Parameters and Emission Rates.....3-4

Table 3-3. Point Source Model Emission Inputs for Nearby Sources.....3-5

Table 3-4. PSD Baseline and Trigger Dates for Guam3-6

Table 3-5. GUM Surface Characteristics 3-10

Table 3-6. GUM Meteorological Data Recovery 3-10

Table 3-7. Surface Moisture Determination 3-11

Table 3-8. Classification of Land Use Types 3-15

Table 4-1. PSD Significant Impact Levels and Significant Monitoring Concentrations.....4-2

Table 4-2. MERP Based Estimated Secondary PM_{2.5} (Worst-Case Load).....4-4

Table 4-3. MERP Based Estimated Secondary PM_{2.5} (Full Load).....4-4

Table 4-4. MERP Based Estimated O₃ Project Impact (Worst-Case Load) 4-6

Table 4-5. MERP Based Estimated O₃ Project Impact (Full Load)4-7

Table 6-1. Comparison of Sensitive Vegetation Screening Concentrations to NAAQS.....6-3

1. INTRODUCTION

This protocol is submitted to the United States Environmental Protection Agency (EPA) Region 9 to describe the procedures proposed to be used in an application for a Prevention of Significant Deterioration (PSD) permit for a new 180 megawatt (MW, nominal) power plant to be constructed by Wärtsilä Development & Financial Services, Inc. (Wärtsilä) for Guam Power Authority (GPA). The proposed project would be located on the northern edge of Tamuning, Guam. Figure 1-1 shows the proposed project location.

Wärtsilä proposes to install and operate ten Wärtsilä reciprocating internal combustion engine (RICE) generators in a Flexicycle configuration. Each engine will be equipped with a waste heat recovery steam generator, and the plant will have a single steam turbine with condenser. The ICEs will be cooled with closed loop radiators; the steam cycle will use either wet or dry cooling. If wet cooling is selected, the project equipment will include cooling towers.

The Wärtsilä generators are four-stroke compression ignition engines that will initially be fueled with diesel with a maximum sulfur content of 15 ppm. GPA expects that liquefied natural gas (LNG) will eventually be available in Guam, and at that time the engines would be fueled with LNG.

Figure 1-1. Proposed Project Location



This protocol addresses the PSD Class I and Class II air quality modeling methodology for the proposed project. The methodology described in this protocol is consistent with the EPA guidelines including “Appendix W to Part 51 – Guideline on Air Quality Models” (*Guideline*).

Key components of this protocol include:

- Preliminary estimates of project emissions;
- Proposed modeling procedures for the project:
 - AERMOD will be used to determine the project’s ambient impact, PSD Class II Increment consumption, and ambient impact on soils and vegetation;
 - National Weather Service (NWS) data will be used as input into AERMOD;
 - Ozone monitoring data collected by the Hawaii Department of Health at Sand Island will define the background ozone concentrations;
 - Background concentrations of pollutants for which modeled impacts exceed significant impact levels (expected to be NO₂, PM₁₀ and PM_{2.5}) will be determined by modeling emissions from existing permitted sources within 10 km of the of the proposed project site, plus the Piti/Cabras power plant. Due to the inherent conservatism of EPA guideline models, this approach is expected to provide conservatively high background concentrations for the project area. Background conditions will be verified by limited preconstruction monitoring that will be carried out in parallel with the permitting process; and
- Proposed methods to complete the Additional Impact Analysis.

2. APPLICABILITY OF PREVENTION OF SIGNIFICANT DETERIORATION

The PSD regulations (Title 40, Code of Federal Regulations, Part 52, Section 21 (40 CFR §52.21) define a major stationary source as:

- Any source belonging to a list of 28 source categories which emits or has the potential to emit 100 tons per year (tpy) or more of any pollutant regulated under the Clean Air Act, or
- Any other source which emits or has the potential to emit such pollutants in amounts equal to or greater than 250 tpy.

Guam is designated as either attainment or unclassifiable for all of the National Ambient Air Quality Standards (NAAQS) for all pollutants except for SO₂. Therefore, a PSD review is required for all pollutants with project emissions above the PSD significance level. Table 2-1 shows the proposed project is expected to be subject to PSD review for:

- CO (carbon monoxide),
- NO_x (nitrogen oxides),
- O₃ (ozone) (due to precursors VOC (volatile organic compounds) and NO_x),
- PM (particulate matter)¹,
- PM₁₀ (particles with an aerodynamic diameter less than or equal to 10 micrometers)²,
- PM_{2.5} (particles with an aerodynamic diameter less than or equal to 2.5 micrometers)², and
- Greenhouse Gases (GHGs).

If the wet cooling option is selected, PM₁₀/PM_{2.5} emissions from the cooling tower will also be included in the evaluation of project emissions and ambient impacts.

¹ All particulate matter emitted from the proposed engines is assumed to be in the PM_{2.5} size range. Therefore, PM emissions will be equivalent to directly emitted PM₁₀ emissions and PM will not be discussed further.

² PM_{2.5} emissions and PM₁₀ emissions include gaseous emissions from a source or activity, which condense to form particulate matter at ambient temperatures. On or after January 1, 2011, such condensable particulate matter must be accounted for in applicability determinations and in establishing emissions limitations for PM_{2.5} and PM₁₀ in PSD permits (40 CFR §52.21(b)(50)(i)(a)).

Table 2-1. Preliminary Project Emissions

Pollutant	Scenario	Unit 1, 2, 3, 4, 5, 6, 7 8, 9 or 10 ^{A,B}		Number of Units	Total Project Emissions ^B (tpy)	PSD Significant Level ^C (tpy)	Significant Increase (Yes/No)
		(lb/hr)	(tpy)				
SO ₂	Normal	0.22	0.83	10	8.3		
	Startup	0.22	0.12	10	1.2		
	Total		0.95		9.5	40	No
CO	Normal	6.9	26.3	10	263		
	Startup	7.8	3.6	10	36		
	Total		29.9		299	100	Yes
NO _x	Normal	19.7	75.5	10	755		
	Startup	259.8	129.4	10	1294		
	Total		204.9		2,049	40	Yes
PM	Normal	5.5	21.1	10	211		
	Startup	7.2	3.9	10	39		
	Total		25.0		250	25	Yes
PM ₁₀ ^D	Normal	5.5	21.1	10	211		
	Startup	7.2	3.9	10	39		
	Total		25.0		250	15	Yes
PM _{2.5} ^{D,E}	Normal	5.5	21.1	10	211		
	Startup	7.2	3.9	10	39		
	Total		25.0		250	10	Yes
VOC	Normal	7.9	30.2	10	302		
	Startup	10.3	5.5	10	55		
	Total		35.7		357		
O ₃ ^F	(NO _x)			10	2,049	40	Yes
	(VOC)			10	357	40	
Lead		0.002	0.009	10	0.09	0.6	No
Fluorides		0.035	0.152	10	1.52	3	No
Sulfuric Acid Mist (H ₂ SO ₄)		0.141	0.618	10	6.18	7	No
Hydrogen Sulfide (H ₂ S)		Not Expected		10	--	10	No
Total Reduced Sulfur (TRS)		Not Expected		10	--	10	No
Reduced Sulfur Compounds		Not Expected		10	--	10	No
MWC Organics		Not Expected		10	--	3.5E-06	No
MWC Metals		Not Expected		10	--	15	No
MWC Acid Gases		Not Expected		10	--	40	No
CO ₂ e		22,791	99,826	10	998,261	75,000	Yes

^A See Appendix A for the emission calculations.

^B The listed project emissions (i.e., short-term emissions) represent the project's potential to emit (PTE) emissions. Annual tpy values are based on each unit operating 21 hours per day at normal conditions and 3 hours per day in startup mode.

^C Non-GHG significant levels from 40 CFR §52.21(b)(23)(i). GHG (i.e., CO₂e) significant level from 40 CFR §52.21(b)(49)(iv).

^D Per 40 CFR §52.21(b)(50)(i)(a) PM_{2.5} emissions and PM₁₀ emissions shall include gaseous emissions from a source or activity which condense to form particulate matter at ambient temperatures. On or after January 1, 2011, such condensable particulate matter shall be accounted for in applicability determinations and in establishing emissions limitations for PM_{2.5} and PM₁₀ in PSD permits.

^E In addition to the 10 tpy significant level for direct PM_{2.5} emissions, the project is significant for PM_{2.5} if SO₂ or NO_x emissions exceed 40 tpy (40 CFR §52.21(b)(23)(i)).

^F The project is significant for O₃ if NO_x or VOC emissions exceed 40 tpy (40 CFR §52.21(b)(23)(i)).

3. AMBIENT IMPACT AND PSD CLASS II INCREMENT MODELING INPUTS

All modeling will be performed in compliance with EPA guidance, including the *Guideline*.

3.1. MODEL SELECTION

EPA's recommended dispersion model, AERMOD (version 18081), will be used in the modeling analysis. AERMOD is a steady-state plume model capable of modeling simple, intermediate, and complex terrain receptors. In the stable boundary layer (nighttime), it assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer (daytime) the probability density function describing the horizontal distribution is assumed to be Gaussian, while the vertical distribution is assumed to be bi-Gaussian. AERMOD also contains the PRIME algorithm which incorporates the two fundamental features associated with building downwash: (1) enhanced plume dispersion coefficients due to the turbulent wake, and (2) reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake (EPA, 2018a and EPA, 2018d).

The modeling will be conducted using AERMOD's regulatory default options. The NO₂ modeling will follow the three tier NO₂ modeling approach for the conversion of nitric oxide (NO) to NO₂ described in the *Guideline* (Section 4.2.3.4). The three tiers are:

- Tier 1 – Assume total conversion of NO to NO₂.
- Tier 2 – Use the Ambient Ratio Method 2 (ARM2), which multiplies the modeled NO_x impacts by estimates of representative NO₂/NO_x equilibrium ratios based on ambient levels of NO₂ and NO_x. The national default for ARM2 includes a minimum ambient NO₂/NO_x ratio of 0.5 and a maximum ambient ratio of 0.9. An alternative minimum ambient NO₂/NO_x ratio based on the source specific in-stack NO₂/NO_x ratios will be used in the modeling study. The source specific in-stack NO₂/NO_x ratios are discussed in Section 3.2.1. The project impact modeling will use ARM2. The cumulative impact modeling will use ARM2, provided the Tier 3 method is not required.
- Tier 3 – Perform a detailed screening analysis on a case-by-case basis. EPA has implemented two Tier 3 options, Ozone Limiting Method (OLM) and Plume Volume Molar Ratio Method (PVMRM), into AERMOD as regulatory options. Appendix B contains the demonstration that OLM and PVMRM are appropriate for this project. Both OLM and PVMRM require representative source specific in-stack NO₂/NO_x ratios and background O₃ concentrations. The source specific in-stack NO₂/NO_x ratios are discussed in Section 3.2.1. The representative background O₃ concentrations are discussed in Section 3.5.

AERMOD (starting with version 11059) is capable of calculating the distribution of daily maximum 1-hour values. The daily maximum 1-hour values are calculated when the pollutant ID is either "SO₂" or "NO₂" and the only short-term averaging period specified is "1-hour." When modeling with 5 years of NWS meteorological data, the receptor-by-receptor 5-year average serves as an unbiased estimate of the 3-year average for comparison to the 1-hour SO₂, 1-hour NO₂, and 24-hour PM_{2.5} National Ambient Air Quality Standard (NAAQS) (EPA, 2010b; EPA, 2010c; EPA, 2014).

Controlling modeled concentrations for the percentile based 1-hour SO₂, 1-hour NO₂, and 24-hour PM_{2.5} NAAQS are described below:

- The 1-hour SO₂ NAAQS controlling modeled concentration is the 99th percentile (4th high for one year) daily maximum 1-hour average SO₂ concentration.
- The 1-hour NO₂ NAAQS controlling modeled concentration is the 98th percentile (8th high for one year) daily maximum 1-hour average NO₂ concentration.

- The 24-hour PM_{2.5} NAAQS controlling modeled concentration is the 98th percentile (8th high for one year) daily PM_{2.5} concentration.

For comparison to the NAAQS, the background concentrations described in Section 3.5 will be added to the controlling modeled concentrations.

3.2. PROJECT AND EXISTING EMISSIONS

3.2.1. Project Emissions

The project is comprised of ten Wärtsilä 18V50DF generating units. Table 3-1 lists the approximate UTM coordinates of the proposed stacks. The *Guideline* (Section 8.2.2.d) requires changes in operating conditions that affect the physical emission parameters (e.g., release height, initial plume volume, and exit velocity) of the project sources be considered to ensure that maximum project impacts are determined. Therefore, stack parameters and emissions were developed for full load, minimum load, and startup. Table 3-2 lists the modeled emission rates and stack parameters for the proposed units. Wärtsilä proposes to locate multiple stacks within one (1) diameter of each other in order to enhance plume rise.

The plumes from multiple closely-spaced stacks merge, enhancing plume rise. AERMOD does not explicitly account for this enhanced plume rise. However, the use of a pseudo stack diameter in AERMOD based on the total volume flow rate of the stacks will account for the enhanced plume rise. EPA has allowed this technique on a case-by-case basis.³ The judgement as to whether combining flows is appropriate includes:

- Stack locations – Only stacks located within 1 diameter of each other will be treated as a merged source.
- Stack height and diameter – All of the stacks treated as a merged source will have the same stack height and diameter.
- Stack emission parameters (temperature, momentum or volume flow, emission rates, etc.) - All of the stacks treated as a merged source will have the same emission parameters.

The PSD regulations (40 CFR 51.118(a) and 40 CFR 52.21(h)) contain limits on the use of other dispersion techniques. Dispersion techniques are defined in 40 CFR 51.100(hh)(1) as “any technique which attempts to affect the concentration of a pollutant in the ambient air by...increasing final exhaust gas plume rise by...selective handling of exhaust gas streams so as to increase the exhaust gas plume rise.” However, 40 CFR 51.100(hh)(2) exempts the merging of exhaust gas streams when the facility is originally designed and constructed with merged gas streams. The proposed grouping of the stacks is designed to take advantage of the merged plume effects.

During startup, the unit is expected to reach full load within 5 minutes of the initial firing. The SCR and oxidation catalyst systems become fully functional once the respective catalyst reaches the operating temperature, within approximately 30 minutes following initiation of fuel flow. The time for each catalyst to reach the operating temperature is dependent on how long the unit was shut down. The oxidation catalysts reach their operating temperature before the SCR catalysts. Startup emissions were provided for the following scenarios:

- Cold Startup – when the catalyst temperature is close to ambient temperature. Cold starts are expected after overhaul periods or when the engine has not been operated during the last 1-2 days.
- Warm Startup – when the catalyst temperature is above ambient but less than 100 °C. Warm starts are expected after the engine has not been operated for 12 hours, but less than 24 hours.

³ Model Clearinghouse Information Storage and Retrieval System Record Details - OH GM Defiance Bubble (97-V-02)

- Hot Startup – when the catalyst temperature is greater than 100 °C. Hot starts are expected after the engine has been operated within the previous 12 hours.

The short-term startup emissions listed in Table 3-2 are based on the worst-case startup scenario (cold catalysts). The long-term startup emissions listed in Table 3-2 are based the worst-case combination of 3 startups per day (1 cold startup, 1 warm startup, and 1 hot startup). Unit shutdowns occur very quickly and emissions greater than normal levels during shutdowns are not expected. Appendix A contains the emission rate calculations.

The source specific NO₂/NO_x in-stack ratio for the proposed units will be based on data from recent PSD permits for similar units and EPA's NO₂/NO_x In-Stack Ratio (ISR) Database.⁴ The following summarizes the measured NO₂/NO_x in-stack ratios for diesel engines with a displacement of greater than 30 liters per cylinder:

- Dutch Harbor Power Plant tested a Wärtsilä Model 12V32C DEG. EPA's ISR Database lists a NO₂/NO_x in-stack ratio of 5.52% at 50% load.
- Dutch Harbor Power Plant tested a Caterpillar C-280 DEG. EPA's ISR Database lists a NO₂/NO_x in-stack ratio of 4.5% at 100% load.
- Tor Viking II tested a MaK/6M32 (rated at 3,784 hp) main propulsion diesel engine equipped with SCR and diesel oxidation catalyst. EPA's Alpha⁵ ISR Database lists NO₂/NO_x in-stack ratios for 30%, 40%, 60%, and 80% loads ranging from 4.24% to 15.93%. Of the 7 tests listed, only one had an in-stack ratio greater than 15%.
- Tor Viking II tested a MaK/8M32 (rated at 5,046 hp) main propulsion diesel engine equipped with SCR and diesel oxidation catalyst. EPA's Alpha⁵ ISR Database lists NO₂/NO_x in-stack ratios for 30%, 40%, and 80% loads ranging from 4.71% to 9.27%.
- Vladimir Ignatuk tested a Stork/8TM410 (rated at 5,720 hp) main propulsion diesel engine. EPA's Alpha⁵ ISR Database lists NO₂/NO_x in-stack ratios for 40%, 60%, and 80% loads ranging from 8.16% to 14.79%.

In addition to the above test data, the PSD permitting of six Wärtsilä Model 20V34DF reciprocating engines at the Hawaiian Electric Company Schofield Generating Station (Covered Source Permit No. 0793-01-C, issued September 6, 2016) relied on a 15% NO₂/NO_x in-stack ratio in the Ambient Impact Analysis.

The data from these units support the use a source specific NO₂/NO_x in-stack ratio of 10% for the startup scenario (when the SCR catalyst is not yet at operating temperature), and 15% for the full load and minimum load scenarios, as conservatively high estimates for the proposed units.

If the project design includes a cooling tower, the cooling tower will be modeled as a series of point sources, with associated diameter, exit temperature, and exit velocity. Downwash effects from the cooling tower structure will be evaluated. Particulate emissions from the cooling tower will be calculated using the design water circulation rate, the guaranteed drift rate and the maximum Total Dissolved Solids (TDS) content of the cooling water. Potential emissions of PM₁₀ and PM_{2.5} will be determined using the techniques developed by Reisman and Frisbie⁶ and detailed in a New Mexico Environment Department Air Quality Bureau Technical Memo⁷

⁴ <https://www.epa.gov/scram/nitrogen-dioxidenitrogen-oxide-stack-ratio-isr-database>

⁵ The data listed in the "Alpha" database does not satisfy the requirements of EPA's formal collection effort.

⁶ Calculating Realistic PM₁₀ Emissions from Cooling Towers, Abstract No. 216 Session No. AS-1b, J. Reisman and G. Frisbie, Greystone Environmental Consultants, Inc.

⁷ New Mexico Environment Department, Air Quality Bureau, Technical Memorandum: Calculating TSP, PM-10 and PM-2.5 from Cooling Towers, September 9, 2013. Available at <https://www.env.nm.gov/aqb/permit/documents/PermittingGuidanceforCoolingTowerParticulateEmissions.pdf>

Table 3-1. Preliminary Stack Locations

NAD 83 - Zone 55				
Unit	UTM Coordinates		Base Elevation ^A	
	Easting (m)	Northing (m)	(ft)	(m)
1	263725.5	1496552.5	258.0	78.63
2	263728.5	1496554.0	258.8	78.87
3	263731.5	1496555.5	259.5	79.09
4	263727.5	1496548.5	257.5	78.48
5	263730.5	1496550.0	258.4	78.76
6	263733.5	1496551.5	259.4	79.06
7	263749.5	1496505.5	255.3	77.83
8	263752.0	1496506.5	256.0	78.03
9	263751.0	1496502.0	255.2	77.80
10	263753.5	1496503.0	256.0	78.03

^A Base elevations obtained from AERMAP

Table 3-2. Preliminary Wärtsilä 18V50DF Modeled Stack Parameters and Emission Rates

Load	Stack Parameters ^A							Modeled Emissions (g/s) ^A						NO ₂ /NO _x
	Diameter		Height		Flow	Velocity	Temp.	SO ₂	NO _x		CO	PM ₁₀ /PM _{2.5}		In-Stack
	(ft)	(m)	(ft)	(m)	(m ³ /s)	(m/s)	(K)		Short-Term	Long-Term		Short-Term	Long-Term	Ratio ^B
Three (3) Plumes Merged														
100%	9.09	2.77	131	40.00	134.10	22.23	464.15	8.187E-02	7.446	7.446	2.597	2.078	2.078	15%
50%	9.09	2.77	131	40.00	73.20	12.14	455.15	4.431E-02	4.611	4.611	1.403	1.685	1.685	15%
Startup ^C	9.09	2.77	131	40.00	177.15	29.37	613.15	8.187E-02	98.19	17.685	2.964	2.156	2.157	10%
Two (2) Plumes Merged														
100%	7.42	2.26	131	40.00	89.40	22.23	464.15	5.458E-02	4.964	4.964	1.731	1.385	1.385	15%
50%	7.42	2.26	131	40.00	48.80	12.14	455.15	2.954E-02	3.074	3.074	0.935	1.124	1.124	15%
Startup ^C	7.42	2.26	131	40.00	118.10	29.37	613.15	5.458E-02	65.46	11.790	1.976	1.437	1.438	10%

^A See Appendix A for data sources and supporting calculations. The listed modeled emissions are the total emissions from the multiple units.

^B The source-specific NO₂/NO_x in-stack ratios are discussed in Section 3.2.1.

^C During startup, the units reach the 100% load within 5 minutes of the initial firing. Modeled short-term emissions are conservatively based on all ten (10) units in continuous startup. Modeled long-term emissions are based on 3 startups per day per unit.

3.2.2. Nearby Sources

A cumulative impact analysis is expected to be required for PM₁₀, PM_{2.5}, and NO_x. The *Guideline* (Section 8.3.3) specifies that all sources in the vicinity of the project that are not adequately represented by ambient monitoring background data should be explicitly modeled. Existing sources that cause a significant concentration gradient in the vicinity of the project are not likely to be adequately characterized by the monitored background data. The number of nearby sources to be explicitly modeled in the air quality analysis is expected to be few except in unusual situations.

EPA’s March 1, 2011 memorandum concludes that the most appropriate data to use for compliance demonstrations for the 1-hour NO₂ NAAQS are those based on emissions scenarios that are continuous or frequent enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations. Emergency generators located at commercial facilities (e.g., hotels, hospitals, etc.) are not expected to operate enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations and will not be included in the 1-hour NO₂ modeling. Average hourly emission rates⁸ will be used in place of the maximum hourly emission rates for non-emergency intermittent sources.

The areas with significant concentration gradients from the project are expected to occur within 10 km of the project site. Because no monitoring data are available to represent existing sources on Guam, all permitted sources within 10 km of the project site plus the Piti/Cabras power plant, will be explicitly modeled. Modeled background sources include the existing GPA Dededo, Macheche, and Yigo power plants, which are located within 10 km of the project site. Additional details are provided in Section 3.5.

The *Guideline* (Table 8-2) specifies the emissions input data for NAAQS and PSD increment modeling. The *Guideline* (Table 8-2) allows the model user to account for actual operations in developing the emissions inputs for dispersion modeling of nearby sources.

Table 3-3 lists the emissions input data requirements for nearby sources.

Table 3-3. Point Source Model Emission Inputs for Nearby Sources

Averaging Time	Emissions Limit (lb/MMBtu)	X	Operating Level (MMBtu/hr)	X	Operating Factor (hrs/yr)
Annual & quarterly	Maximum allowable emission limit or federal enforceable permit limit.		Annual level when actually operating , averaged over the most recent 2 years.		Actual operating factor (hours) averaged over the most recent 2 years.
Short term (≤24 hours)	Maximum allowable emission limit or federal enforceable permit limit.		Annual level when actually operating , averaged over the most recent 2 years.		Continuous operation , i.e., all hours of each time period under consideration (8,760 hrs/yr).

Source: Table 8-2 of the Guideline

The “annual level when actually operating, averaged over the most recent 2 years” will be calculated by dividing the average heat input for most recent 2 years available by the average operating hours for the respective

⁸ For example, the average hourly emission rate for a source with an annual operating limit of 500 hours equals the maximum hourly emission rate times 500/8760.

calendar years, if these data are available. If actual heat input data are not available, the analysis will assume full-time, full load operation for non-emergency, non-intermittent units.

The PSD increment evaluation requires the inclusion of all increment-consuming sources. PSD increments have not been established for 1-hour SO₂ and 1-hour NO₂. Table 3-4 lists the PSD baseline and trigger dates for Guam.

Table 3-4. PSD Baseline and Trigger Dates for Guam

Pollutant	Averaging Periods	Minor Source Baseline Date	Major Source Baseline Date	Trigger Date
NO ₂	Annual	1992 ^A	February 8, 1988	February 8, 1988
PM ₁₀	24-hour and Annual	1992 ^A	January 6, 1975	August 7, 1977
PM _{2.5}	24-hour and Annual	2018 ^B	October 20, 2010	October 20, 2011

^A PSD GU 92-01 for the Dededo Generating Station, issued April 16, 1993.

^B This application will be the first PSD application after the PM_{2.5} major source baseline date.

3.3. AERMOD METEOROLOGICAL DATA

AERMOD uses several different boundary layer parameters to model how pollutants disperse in the atmosphere. Many of these parameters are not directly measured, but are calculated from other variables that are more easily measured. AERMET, EPA's meteorological processor for AERMOD, uses observed near-surface wind and temperature and site-specific surface characteristics to estimate these boundary layer parameters (EPA, 2018b). The following surface characteristics are input into AERMET during the stage 3 processing:

- Surface roughness length (z_o) – the height above the ground at which horizontal wind velocity is typically zero,
- Noon-time albedo (r) – the fraction of radiation reflected by the surface, and
- Daytime Bowen ratio (B_o) – the ratio of the sensible heat flux (H) to the latent heat flux (λE).

In the AERMOD Implementation Guide, EPA recommends the following methodology to determine these surface characteristics:

1. *The determination of the surface roughness length should be based on an inverse-distance weighted geometric mean for a default upwind distance of 1 kilometer relative to the measurement site. Surface roughness length may be varied by sector to account for variations in land cover near the measurement site; however, the sector widths should be no smaller than 30 degrees.*
2. *The determination of the Bowen ratio should be based on a simple unweighted geometric mean (i.e., no direction or distance dependency) for a representative domain, with a default domain defined by a 10km by 10km region centered on the measurement site.*
3. *The determination of the albedo should be based on a simple unweighted arithmetic mean (i.e., no direction or distance dependency) for the same representative domain as defined for Bowen ratio, with a default domain defined by a 10km by 10km region centered on the measurement site.*

EPA developed AERSURFACE to calculate the surface characteristics based on this recommended methodology. AERSURFACE reads land cover values from the United States Geological Survey (USGS) 1992 National Land Cover Dataset (NLCD92). However, the NLCD92 is not available for Guam. Therefore, the surface characteristics for the Guam International Airport meteorological station (GUM) were obtained from the EPA's "SO₂ NAAQS Designations Modeling Analyses, Results and Documentation for the Island of Guam" report, dated January 13,

2017.⁹ The surface characteristic values presented in Table 3-5 are based on the Coastal Change Analysis Program (C-CAP) data for the territory of Guam from 2005.¹⁰ As is shown in Figure 3-1, GUM is approximately 5.6 km (3.5 miles) to the south-southwest of the project site.

In the *AERMOD Implementation Guide*, EPA states that the determination of representativeness of NWS meteorological data should include a comparison of surface characteristics of the NWS measurement site and source locations, coupled with a determination of the importance of those differences relative to predicted concentrations (EPA, 2018e).

The project site and GUM are located on the north-central portion of the island. No major geographic features impacting the surface conditions or wind patterns exist between the two locations. Therefore, the meteorological data from GUM are considered representative of the project site.

In the *Guideline*, EPA states that five (5) years of NWS meteorological data are adequate to ensure that worst-case meteorological conditions are represented in the model results. GUM surface and upper air data from January 1, 2012 to December 31, 2016 are proposed.

AERMET (version 18081) will be used to create the required meteorological input files. AERMINUTE (version 15272) was used to calculate the hourly wind speed and direction from the 1-minute and 5-minute Automated Surface Observing System (ASOS) data.¹¹ Run logs of the AERMET and AERMINUTE meteorological data file processing will be provided as part of the final modeling report supporting the PSD permit application. The following AERMET stage 3 processing options will be used:

- > METHOD WIND_DIR RANDOM
- > METHOD UASELECT SUNRISE
- > METHOD STABLEBL ADJ_U*, and
- > THRESH_1MIN 0.5.

Figure 3-2 presents a wind rose of the 5 years of data. The hourly values of wind speed and direction were measured at 10 m (32.8 ft). Table 3-6 shows the GUM meteorological data recovery for the 5-year period. The total percent of calm, variable¹², and missing data (i.e., non-calculable hours) is less than 10%.

Based on EPA's guidance in the AERSURFACE user's guide (EPA, 2008), the surface moisture conditions for each modeled year are based on the annual precipitation for each year compared to the annual precipitation from the 30-year climatological period (1981-2010). The surface moisture is "wet" if the annual precipitation is in the upper 30th percentile, "dry" if the annual precipitation is in the lower 30th percentile, and "average" if the annual precipitation is in the middle 40th percentile of the climatological period. Table 3-7 compares the annual precipitation from each modeled year to the upper 30th, lower 30th, and middle 40th percentiles of the annual precipitation from the 1981-2010 climatological period. The surface moisture conditions were average in 2011 and 2013, dry in 2012, and wet in 2014 and 2015.

⁹ https://www.epa.gov/sites/production/files/2017-01/documents/final_so2_modeling_report_drr_1.13.17.pdf

¹⁰ <https://coast.noaa.gov/ccapftp/>

¹¹ The 1-minute and 5-minute ASOS data were downloaded from the National Centers for Environmental Information (NCEI): <ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/> and <ftp://ftp.ncdc.noaa.gov/pub/data/asos-fivemin/>. Data prior to September 2013 are not available.

¹² The wind direction is reported as variable when the wind direction varies by 60 degrees or more during the 2-minute evaluation period and the 2-minute wind speed is 6 knots or less. Since wind direction is not recorded, AERMOD classifies these hours as missing.

GUM upper air soundings were input into AERMET. Missing upper air soundings from GUM were replaced with the respective soundings from Chuuk International Airport, Micronesia (TKK) which is located approximately 1,000 km to the southeast of GUM.

Figure 3-1. Project Site and GUM Locations



Figure 3-2. GUM Wind Rose (2012-2016)

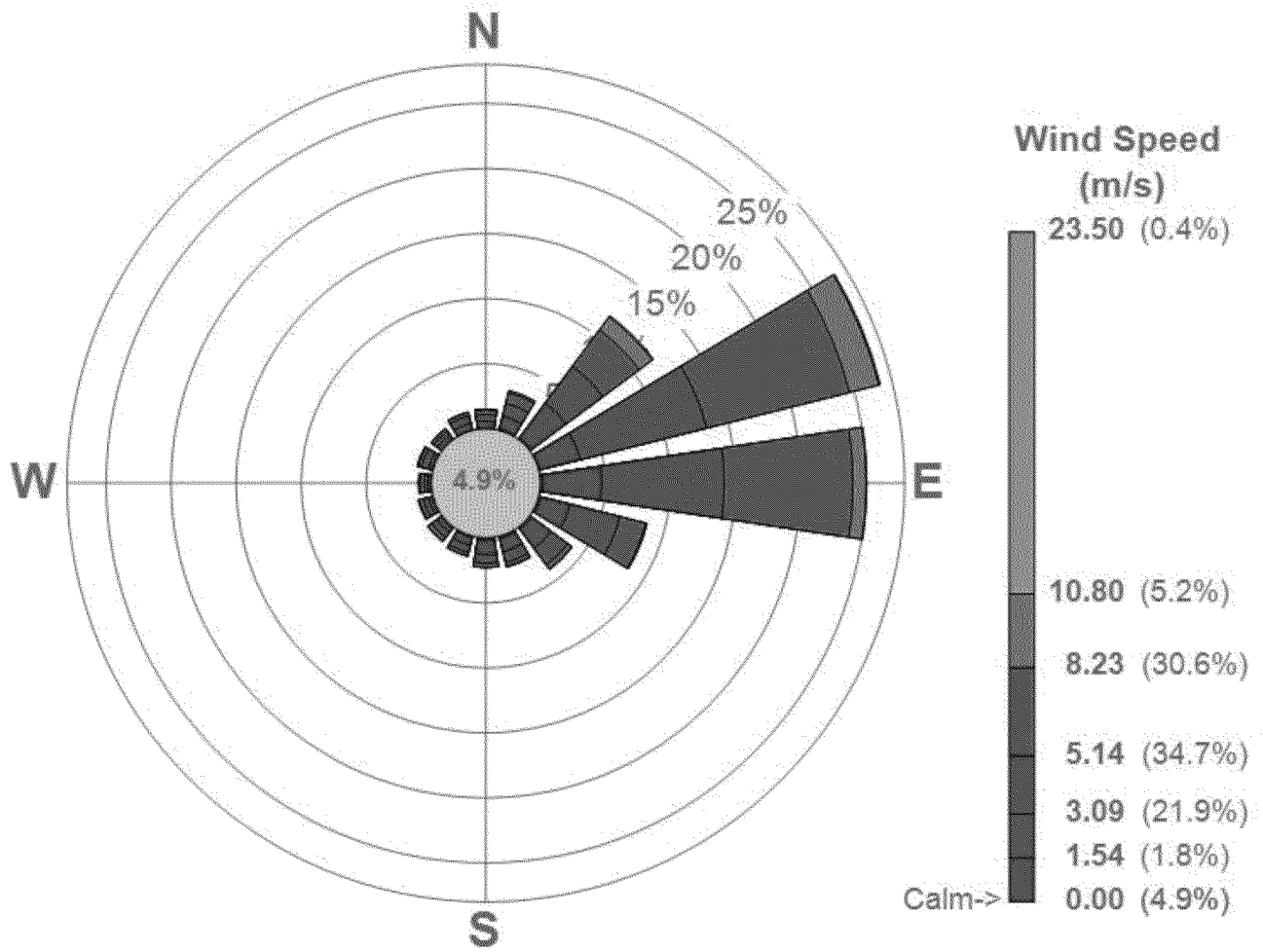


Table 3-5. GUM Surface Characteristics

Surface Roughness							
Sector	Sector Arc (Degrees from North)		Sector Width (Degrees)	Surface Roughness Length (m)	Bowen Ratio		Albedo
	Start	End			Wet	Average	
1	0	45	45	0.064			
2	45	90	45	0.076			
3	90	135	45	0.142			
4	135	180	45	0.178	0.27	0.37	0.14
5	180	225	45	0.156			
6	225	270	45	0.116			
7	270	315	45	0.068			
8	315	360	45	0.061			

Source: EPA's "SO₂ NAAQS Designations Modeling Analyses, Results and Documentation for the Island of Guam" report, dated January 13, 2017.

Table 3-6. GUM Meteorological Data Recovery

Year	Hours Processed	Calm Winds ¹		Variable Winds ²		Missing Data ³		Total Non-Calculable	
		Number of Hours	Percent of Period	Number of Hours	Percent of Period	Number of Hours	Percent of Period	Number of Hours	Percent of Period
2012	8,784	726	8.3%	59	0.7%	48	0.5%	833	9.5%
2013	8,760	486	5.5%	37	0.4%	11	0.1%	534	6.1%
2014	8,760	363	4.1%	10	0.1%	1,491	17.0%	1,864	21.3%
2015	8,760	289	3.3%	5	0.1%	1	0.0%	295	3.4%
2016	8,784	273	3.1%	10	0.1%	24	0.3%	307	3.5%
Total	43,848	2,137	4.9%	121	0.3%	1,575	3.6%	3,833	8.7%

¹ Calm hours are when the wind speed and direction are both zero

² Variable wind direction is reported when the wind direction varies by 60 degrees or more during the 2-minute evaluation period and the 2-minute wind speed is 6 knots or less. The wind speed is greater than zero and the wind direction is missing.

³ Missing data are when upper air, cloud cover, temperature, both the wind speed and direction data are missing.

Table 3-7. Surface Moisture Determination

Climatological (1981-2010)			Annual	
Annual Precip. (inch)			Precip.	Wet, Dry
Bottom 30 th %	Top 30 th %	Year	(inch)	Or Average?
88.3	110.7	2012	99.1	Average
		2013	101.6	Average
		2014	118.5	Wet
		2015	115.8	Wet
		2016	94.0	Average

3.4. AERMOD RECEPTOR DATA AND MODELING DOMAIN

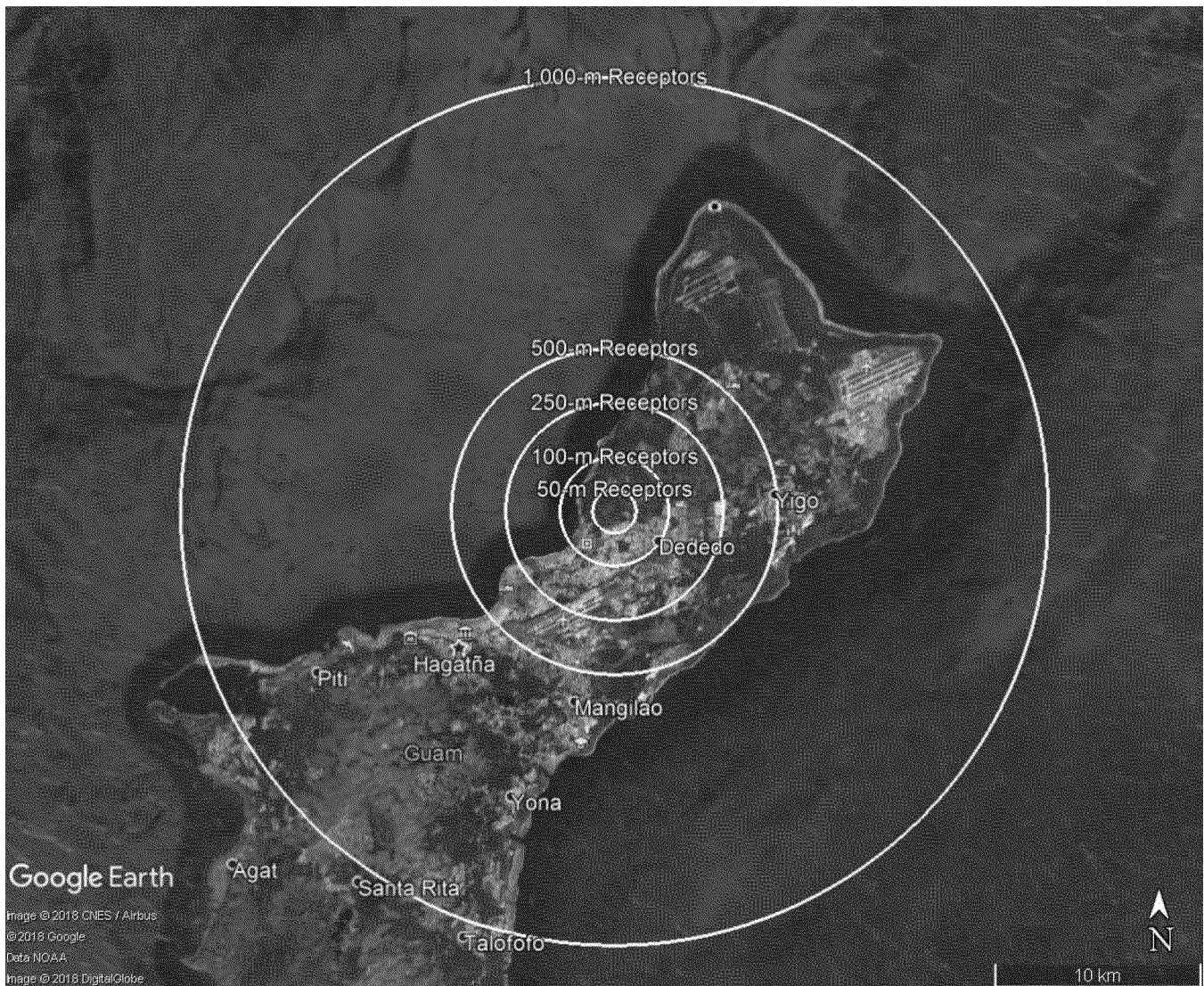
Figure 3-3 shows the initial modeling grid consisting of:

- 25-m spaced receptors along the fence line (i.e., that area to which public access is physically restricted),
- 50-m spaced receptors centered at 263775 m E, 1496525 m N to 1.0 km,
- 100-m spaced receptors from 1.0 km to 2.5 km,
- 250-m spaced receptors from 2.5 km to 5 km,
- 500-m spaced receptors from 5.0 km to 7.5 km, and
- 1,000-m spaced receptors from 7.5 km to 20 km.

Additional receptors will be added as needed to areas of maximum impact to ensure the maximum concentrations are identified.

EPA's AERMAP (version 18081) program will be used to determine the receptor elevations and height scales. AERMOD uses the receptor's height scale to determine if the plume is terrain following or terrain impacting. The AERMAP User's Guide (EPA, 2018c) states that the domain boundary must include all terrain features that exceed a 10% elevation slope from any given receptor. USGS National Elevation Dataset (NED) 1/3 arc-second data covering the entire island of Guam was obtained from the USGS National Map Viewer for input into AERMAP to determine the receptor elevations and height scales. Additional NED 3 arc-second data was included for the over-water receptors located outside the data boundary of the 1/3 arc-second data. The PSD permit application support document will include run logs of the AERMAP receptor data processing.

Figure 3-3. Initial Receptor Grid



3.5. BACKGROUND CONCENTRATIONS

A cumulative impact analysis is required for any pollutant for which the proposed source's estimated ambient pollutant concentrations exceed the modeling significant impact levels (SILs). The project's controlling modeled concentrations are expected to be above the respective modeling SILs for the following:

- 1-hour and annual NO_2 ,
- 24-hour and annual $\text{PM}_{2.5}$, and
- 24-hour and annual PM_{10} .

Therefore, a cumulative impact analysis will be performed for these pollutants and averaging periods. The cumulative impact analysis takes into account all sources affecting the air quality in an area. In this analysis, the project's impact plus background concentrations are combined and compared to the NAAQS. This step requires defining appropriate background concentrations.

Background concentrations include contributions from nearby sources and other sources (e.g., natural, minor, and distant major sources). The contributions from nearby sources will be included by explicitly modeling these sources.

The existing GPA generating units at Piti/Cabras, Dededo, Macheche, and Yigo are the main significant nearby stationary sources and will be included in the modeling. Therefore, ambient monitoring data is needed to define the other sources in the area.

There are no active ambient air quality monitors on Guam. A search of historical data found the following summary from “Guam and CNMI Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement”¹³ prepared for the U.S. Department of the Navy:

The government of Guam has not collected ambient air quality data since 1991. Therefore, no existing ambient air quality data are available to represent current air quality conditions with respect to the criteria pollutants for which the NAAQS were established. Historical data are available from 1972 through 1991, when ambient air quality data were collected at a number of sites through a USEPA-sponsored monitoring program. The monitored pollutants were total suspended particles (TSP), SO₂, NO₂, and nitrogen monoxide (NO). In 1991, PM₁₀ was monitored in addition to TSP.

Prior to 1991, TSP were monitored at 20 sites, SO₂ at 14 sites, NO₂ at five sites, and NO at one site. In 1991, PM₁₀ was monitored at four sites. In addition to the historical monitoring identified above, the GPA established a network of five stations to measure SO₂ at locations that are not downwind or close to any major EGUs during normal trade wind conditions from the fall of 1999 through the summer of 2000...

Because of the lack of current ambient monitoring data, the existing air quality conditions on Guam cannot be evaluated by a direct comparison of the ambient pollutant concentration levels with the NAAQS. Instead, with the exception of O₃ concentrations, the existing air quality conditions around the site will be based on a modeling assessment of permitted stationary sources located within 10 km of the proposed project site plus the Piti/Cabras power plant.

O₃ is a regional pollutant that is not directly emitted into the atmosphere like the other criteria pollutants. O₃ has an appreciable formation time because the mixing of reactants and products occurs over a large volume of air. Since the mixing of O₃ precursors occurs over a large volume of air, the monitoring of small-scale spatial variability is not necessary. The nearest EPA O₃ monitor is located on the Island of Hawaii. Guam and Hawaii are both remote islands in the Pacific Ocean with limited industrial sources. The majority of O₃ in both locations is expected to be from long range transport.

Tier 3 NO₂ modeling requires concurrent hourly O₃ data. The nearest EPA O₃ monitor with concurrent hourly data is located on the Island of Hawaii. The Hawaii Department of Health (DOH) monitors O₃ at the Kapolei and Sand Island AQM stations on the Island of O‘ahu. DOH’s Kapolei AQM station has had periods with less than 75% data recovery. DOH’s Sand Island AQM station is the state’s SLAMS O₃ monitor and is located at the University of Hawai‘i’s Ānuenue Fisheries. This area is composed of light industrial, commercial, recreational, and harbor units and is approximately 1.5 km southwest (typically downwind) of downtown Honolulu.

DOH’s Sand Island AQM station was selected to provide the concurrent hourly O₃ data if needed for Tier 3 NO₂ modeling. Hourly O₃ data were obtained from EPA’s Air Quality System (AQS) Data Mart for the 5-year period (January 1, 2012 through December 31, 2016) of the NWS meteorological data. Missing observations will be filled using the following three step approach:

1. When one or two consecutive hours are missing, interpolation is used to fill these missing values.

¹³ Appendix I - Air Impact Study (www.Guambuildupeis.us/documents)

2. When three or more consecutive hours are missing, the missing values are filled with the maximum concentration from the same hour from the previous and following day.
3. When three or more consecutive hours are missing and both concentrations for the same hour from the previous and following day were missing, missing values are filled with the maximum concentration from the same hour from the entire calendar year.

The use of the maximum hourly concentrations for data gaps greater than two hours is not expected to result in an underestimation of the missing O₃ concentrations.

3.6. GEP STACK HEIGHT AND BUILDING DOWNWASH

For air quality modeling purposes, the proposed new units will be evaluated in terms of their proximity to nearby structures to determine whether stack effluents may be affected by downwash in the turbulent wake of such structures. AERMOD uses the following building parameters to account for downwash:

- BUILDHGT, the building height,
- BUILDWID, the projected width of the building perpendicular to the flow,
- BUILDLEN, the projected length of the building along the flow,
- XBADJ, the along-flow distance from the stack to the center of the upwind face of the projected building, and
- YBADJ, the across-flow distance from the stack to the center of the upwind face of the projected building.

Building parameters will be obtained using EPA's Building Profile Input Program designed for AERMOD (BPIPPRM – version 04274). BPIPPRM calculates the building parameters for 36 wind directions based on the physical dimensions of the structures surrounding a source. Trinity reviewed information from Google Earth and determined that off-site buildings will not need to be included in the modeling. The final modeling report will provide the preliminary structures and heights entered into BPIPPRM and will include the BPIPPRM input and output files.

The *Guideline* states the use of stack heights greater than the Good Engineering Practice (GEP) stack height in the modeling is prohibited (40 CFR §51.118 and 40 CFR §51.164). Per 40 CFR §51.100 the GEP stack height limit for this project is the greater of:

- 65 meters, measured from the ground-level elevation at the base of the stack, or
- The formula GEP stack height ($GEP_f = H + 1.5L$). Where, H is the structure height, and L is the lesser dimension of the structure (height or projected width). The maximum calculated formula GEP stack height from BPIPPRM is 33.05 meters (108.4 ft).

The proposed stack heights of 40 meters (132.5 ft) are expected to be greater than the formula GEP stack height but less than 65 meter limit; consequently, the stack heights are within acceptable limits.

3.7. URBAN/RURAL CLASSIFICATION

The selection of either rural or urban dispersion coefficients in the air quality modeling follows the procedure provided in the *Guideline*. Categorizing an area as urban or rural is determined by land use classification or population. Section 7.2.1.1.b in the *Guideline* specifies that the land use procedure is considered more definitive; therefore, the land use procedure is used to classify the area around the project site for air quality modeling purposes.

The land use is classified within the total area circumscribed by a 3-km radius circle (A_0) about the source, using the land use typing scheme proposed by Auer (1978).

Table 3-8 defines the land use types, where I1, I2, C1, R2, and R3 represent urban environments, while the other categories designate rural characteristics. Thus, if land use types I1, I2, C1, R2, and R3 (urban) account for 50% or more of the circumscribed area, urban dispersion coefficients should be used. Otherwise, appropriate rural dispersion coefficients are used. As shown in Figure 3-4, the urban land use types are less than 50%. Therefore, the area was classified as rural.

Table 3-8. Classification of Land Use Types

Auer Category	Auer Description
I1*	Heavy industrial
I2*	Light-moderate industrial
C1*	Commercial
R1	Common residential
R2*	Compact residential I
R3*	Compact residential II
R4	Estate residential
A1	Metropolitan natural
A2	Agricultural rural
A3	Undeveloped wasteland
A4	Undeveloped rural
A5	Water surfaces

Source: Auer, 1978

* Urban character

Figure 3-4. Area Surrounding the Project Site (3-km Radius)



4. AMBIENT IMPACT AND PSD CLASS II INCREMENT MODELING METHODOLOGY

This section describes the modeling methodology that will be used to demonstrate that the proposed project does not cause or contribute to the violation of any NAAQS or PSD Class II Increment.

Following the guidance contained in the *Guideline* (Section 9.2.3), the modeling will be conducted in two distinct stages:

- Stage 1 – Project Impact Analysis: This stage models only the impact of the new or modifying source.
- Stage 2 – Cumulative Impact Analysis: This stage models the combined impact of the project and nearby sources and includes the background concentration from other sources not modeled (e.g., natural, minor, and distant major sources).

Each stage involves increasing complexity and details, as required, to demonstrate that the project will not cause or contribute to a violation of any NAAQS or PSD increment. If the project impact analysis demonstrates that a source will not cause or contribute to any potential violation, this alleviates the need for a cumulative impact analysis.

4.1. PROJECT IMPACT ANALYSIS

The project impact analysis (stage 1) determines the potential of the project to cause or contribute to a violation of any NAAQS or PSD increment. If screening or refined modeling indicates that the project will not cause or contribute to any potential violation of any NAAQS or PSD increment then the project impact analysis would generally be sufficient for the required demonstration under PSD (The *Guideline*, Section 9.2.3.c). Table 4-1 lists the significant impact levels (SILs) that will be used to determine if the project has the potential to cause or contribute to a violation. A preliminary project impact analysis as described here determined that the project is expected to be significant for:

- 24-hour PM_{10} ,
- 24-hour and annual $PM_{2.5}$, and
- 1-hour NO_2 .

A cumulative impact analysis (stage 2) is required for the pollutant averaging periods above a SIL. The receptors that indicate the location of significant ambient impacts will be used to define the modeling domain for use in the cumulative impact analysis (The *Guideline*, Section 9.2.3.c). If a modeled pollutant and averaging period impact is below the modeling SIL, there is no impact area and there will be no sources to include in the NAAQS and PSD increment analysis. Under these circumstances, no cumulative impact analysis would be required and no existing sources would need to be considered in the project impact analysis.

Table 4-1. PSD Significant Impact Levels and Significant Monitoring Concentrations

Pollutant	Averaging Period	Modeling Significant Impact Level (SIL) ($\mu\text{g}/\text{m}^3$)	Significant Monitoring Concentration ^A (SMC) ($\mu\text{g}/\text{m}^3$)
SO ₂	1-hr	7.8 ^B	--
	3-hr	25 ^C	--
	24-hr	5 ^C	13
	Annual	1 ^C	--
PM ₁₀	24-hr	5 ^C	10
	Annual	1 ^C	--
PM _{2.5}	24-hr	1.2 ^D	0
	Annual	0.2 ^D	--
NO ₂	1-hr	7.5 ^E	--
	Annual	1 ^C	14
CO	1-hr	2,000 ^C	--
	8-hr	500 ^C	575
Lead	Quarterly	--	0.1
Fluoride	24-hr	--	0.25
H ₂ S	1-hr	--	0.2
TRS	1-hr	--	10
Reduced Sulfur Compounds	1-hr	--	10

^A The SMCs are codified in 40 CFR §52.21(i)(5)(i).

^B EPA's Stephen D. Page memorandum, dated August 23, 2010, "Guidance Concerning the Implementation of the 1-hour SO₂ NAAQS for the Prevention of Significant Deterioration Program," recommends a 1-hour SO₂ SIL of 3 ppb (7.8 $\mu\text{g}/\text{m}^3$).

^C Table C-4 (page C.28) of the October 1990 Draft New Source Review Workshop Manual lists the SILs for 3-hr, 24-hr, and annual SO₂, 24-hour and annual PM₁₀, annual NO₂, and 1-hour and 8-hour CO.

^D EPA's Stephen D Page memorandum, revised August 18, 2016, draft "Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program," recommends a 24-hour SIL of 1.2 $\mu\text{g}/\text{m}^3$ and an annual SIL of 0.2 $\mu\text{g}/\text{m}^3$.

^E EPA's Stephen D. Page memorandum, dated June 29, 2010, "Guidance Concerning the Implementing the 1-hr NO₂ National Ambient Air Quality Standard in Prevention of Significant Deterioration Permits," recommends a 1-hr NO₂ SIL of 4 ppb (7.5 $\mu\text{g}/\text{m}^3$).

The *Guideline* (Section 8.2.2.d) requires changes in operating conditions that affect the physical emission parameters (e.g., release height, initial plume volume, and exit velocity) of the project sources be considered to ensure that maximum project impacts are determined. Therefore, the project impact analysis will evaluate the units operating at full load, minimum load, and startup. The following steps were used to determine the project's maximum impact for each pollutant and averaging period for the preliminary determination of areas of significant concentration gradients; these steps will also be followed for the final project impact analysis:

1. Determine the project's maximum impact for all receptors for all averaging periods for the three operating scenarios (full load, minimum load, and startup) with all ten units operating simultaneously.
2. Compare the project's maximum impact identified in step 1 with the significant monitoring concentrations (SMC) and modeling SIL. Table 4-1 lists the modeling SILs and SMCs.
3. Compare the project's full load impacts with the modeling SILs.

The maximum impacts from the worst-case load scenario for all PSD regulated pollutants are compared to the SMCs and the SILs. Pollutants with maximum project impacts above the SMC require may require pre-construction ambient air monitoring. Project impacts for PM_{2.5} and O₃ are expected to exceed preconstruction monitoring thresholds, and a preconstruction monitoring plan will be prepared for those pollutants. The project impacts for the other PSD pollutant averaging periods are expected to be below the SMCs.

Pollutants and averaging periods with maximum project impacts above the applicable SIL will require a cumulative impact analysis, which will be included in the final report supporting the PSD permit application. The cumulative impact analysis will be conducted for the worst-case and full design load scenarios.

4.2. PM_{2.5} IMPACTS

4.2.1. Preconstruction PM_{2.5} Monitoring Requirements

As disused in Section 3.5, there are no current ambient PM_{2.5} data for Guam. Wärtsilä will be submitting a preconstruction monitoring protocol to address the collection of preconstruction PM_{2.5} monitoring data.

4.2.2. PM_{2.5} Ambient Air Quality Analysis

The discussion above addressed the project's primary impact which will be determined by AERMOD. However, PM_{2.5} is comprised of both primary PM_{2.5}, which is directly emitted into the air, and secondary PM_{2.5}, which forms indirectly from fuel combustion and other sources. Secondary PM_{2.5} forms in the atmosphere from gases. Some of these reactions require sunlight and/or water vapor. Secondary PM_{2.5} includes:

- Sulfates formed from sulfur dioxide emissions from power plants and industrial facilities;
- Nitrates formed from nitrogen oxide emissions from cars, trucks, and power plants; and
- Carbon formed from reactive organic gas emissions from cars, trucks, industrial facilities, forest fires, and biogenic sources such as trees.

AERMOD is not capable of modeling secondary PM_{2.5}. The *Guideline* (Section 5.3.2) recommends the following two tier approach for assessing single-source secondary PM_{2.5} impacts:

- Tier 1 – The first tier involves use of appropriate and technically credible relationships between emissions and ambient impacts developed from existing modeling studies deemed sufficient for evaluating a project's impact. EPA is in the process of developing Modeled Emission Rates for Precursors (MERPs) as a Tier 1 demonstration tool for secondary PM_{2.5}.
- Tier 2 – The second tier involves a more sophisticated case-by-case application of chemical transport modeling.

The term MERP describes a precursor (NO_x and SO₂) emission rate that is expected to result in a change in ambient secondary PM_{2.5} that is less than a specific air quality concentration threshold. Therefore, if the project's precursor emissions are below the MERPs, the project is not expected to cause or contribute to a violation of the NAAQS due to secondary PM_{2.5} formation. Otherwise, if the project's precursor emissions are above the MERPs, the MERPs can be used to estimate the project's secondary PM_{2.5} impact.

The project's secondary PM_{2.5} impact will be estimated using the most conservative (lowest) illustrative MERP values for the Western U.S. listed in Table 7.1 of the draft MERP guidance. Table 4-2 and Table 4-3 provide the estimated secondary PM_{2.5} impact from the project's NO_x and SO₂ emissions for the worst-case and full load scenarios, respectively. The project's primary PM_{2.5} impacts are expected to be above the SIL; therefore, a PM_{2.5} cumulative impact analysis will be required. The cumulative impact analysis will include the project's secondary PM_{2.5} impact.

Table 4-2. MERP Based Estimated Secondary PM_{2.5} (Worst-Case Load)

Precursor	Precursor Emissions ^A (tpy)	MERP ^B	
		Daily PM (tpy)	Annual PM (tpy)
NO _x	2,049	1,075	3,184
SO ₂	9.5	210	2,289
MERP Critical Threshold (µg/m³)		1.2	0.2
Project % of MERP		195%	65%
MERP Secondary PM_{2.5}		2.34	0.13

^A The listed precursor emissions are the worst-case project emissions.

^B The listed MERP is from EPA's draft *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier I Demonstration Tool for Ozone and PM_{2.5} under the PSD Permitting Program* (EPA 454/R-16-006), Table 7.1 for the western U.S.

Table 4-3. MERP Based Estimated Secondary PM_{2.5} (Full Load)

Precursor	Precursor Emissions ^A (tpy)	MERP ^B	
		Daily PM (tpy)	Annual PM (tpy)
NO _x	863	1,075	3,184
SO ₂	9.5	210	2,289
MERP Critical Threshold (µg/m³)		1.2	0.2
Project % of MERP		85%	28%
MERP Secondary PM_{2.5}		1.02	0.06

^A The listed precursor emissions are the worst-case project emissions.

^B The listed MERP is from EPA's draft *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier I Demonstration Tool for Ozone and PM_{2.5} under the PSD Permitting Program* (EPA 454/R-16-006), Table 7.1 for the western U.S.

4.3. CUMULATIVE IMPACT ANALYSIS

The cumulative impact analysis (stage 2) is required for any pollutant and averaging period, which has a modeled project impact (determined in the project impact analysis) greater than the modeling SIL. The *Guideline* (Section 9.2.3.d) specifies that the cumulative impact analysis should be conducted with the same refined modeling methods used to characterize the project impact and then include the appropriate background

concentrations. The resulting design concentrations should be used to determine whether the project will cause or contribute to a NAAQS or PSD increment violation. This determination should be based on:

1. The appropriate design concentration for each applicable NAAQS (and averaging period); and
2. Whether the source's emissions cause or contribute to a violation at the time and location of any modeled violation (i.e., when and where the predicted design concentration is greater than the NAAQS).

For PSD increments, the cumulative impact analysis should also consider the amount of the air quality increment that has already been consumed by other sources, or, conversely, whether increment has expanded relative to the baseline concentration. Therefore, the applicant should model the existing or permitted nearby increment-consuming and increment-expanding sources.

The cumulative impact analysis will be limited to the areas with significant impact area (area with a predicted ambient impact from the proposed project greater than the respective modeling SIL). A preliminary project impact analysis as described above determined that the areas with significant concentration gradients from the project are expected to occur within 10 km of the project site; the modeling report submitted as part of the application support documentation will include this demonstration.

4.3.1. Ambient Air Quality Modeling Analysis

The NAAQS modeling requires the inclusion of nearby existing sources and ambient background concentrations. Section 3.2.2 describes the emissions inventory of nearby existing sources. Section 3.5 describes the incorporation of the ambient background concentration data.

The objective of this step is to demonstrate that the operation of the proposed units does not cause or contribute to a NAAQS violation at any receptor. If modeled violations are found, then the project's contribution to all modeled violations is compared to the modeling SIL to determine whether the project causes or contributes significantly to the modeled violations. If needed, the AERMOD model output option, MAXDCONT, will be used to perform this contribution analysis. The MAXDCONT option is applicable to the 24-hour PM_{2.5}, 1-hour NO₂, and 1-hour SO₂ percentile based NAAQS and can be used to determine the project's contribution to the overall high ranked values (e.g., 8th-highest maximum daily 1-hour, 9th-highest maximum daily 1-hour, etc.).

4.3.2. PSD Class II Increment Analysis

The PSD Class II Increment evaluation requires the inclusion of all increment-consuming sources. PSD Class II Increments have not been established for 1-hour SO₂ and 1-hour NO₂. Table 3-4 lists the baseline dates for the Guam. Nearby sources (as described in Section 3.2.2) will be reviewed to identify any increment-consuming sources that will need to be included in an increments analysis.

The objective of this step is to demonstrate that the operation of the proposed new generating units does not cause or contribute to a PSD Class II Increment violation at any receptor. If modeled violations are found, then the project's contribution to all modeled violations will be compared to the SIL to determine whether the project causes or contributes significantly to any of the modeled violations.

4.4. OZONE ANALYSIS

40 CFR §52.21(c)(50)(i)(f) specifies that projects with a net emissions increase of 100 tpy or more of VOCs shall include an ambient impact analysis including the gathering of ambient air quality data. Table 2-1 shows the project's VOC emissions exceed 100 tpy. Therefore, an analysis of potential effects on ambient O₃ concentrations is required, which includes the collection of preconstruction O₃ monitoring.

4.4.1. Preconstruction Ozone Monitoring Requirements

As disused in Section 3.5, there are no current ambient O₃ data for Guam. Wärtsilä will be submitting a preconstruction monitoring protocol to address the collection of preconstruction O₃ monitoring data.

4.4.2. Ozone Ambient Air Quality Analysis

O₃ is a secondary pollutant; therefore, it cannot be modeled using a traditional point source model such as AERMOD. The *Guideline* (Section 5.3.2) recommends the following two tier approach for assessing single-source O₃ impacts:

- **Tier 1** – The first tier involves use of appropriate and technically credible relationships between emissions and ambient impacts developed from existing modeling studies deemed sufficient for evaluating a project’s impact. EPA is in the process of developing MERPs as a Tier 1 demonstration tool for O₃.
- **Tier 2** – The second tier involves a more sophisticated case-by-case application of chemical transport modeling.

The term MERP describes a precursor emission rate that is expected to result in a change in ambient O₃ that is less than a specific air quality concentration threshold. Therefore, if the project’s precursor emissions are below the MERPs, the project is not expected to cause or contribute to a violation of the NAAQS. Otherwise, if the project’s precursor emissions are above the MERPs, the MERPs can be used to estimate the project’s O₃ impact.

The project’s O₃ impact will be estimated using the most conservative (lowest) illustrative MERP values for the Western U.S. listed in Table 7.1 of the draft MERP guidance. Table 4-4 and Table 4-5 provide the estimated O₃ impact from the project’s NO_x and VOC emissions for the worst-case and full load scenarios, respectively. The analysis showed that project’s VOC and NO_x emissions are above the MERPs. Therefore, the MERPs will used to calculate the project’s O₃ contribution which will be added to the background O₃ for comparison to the NAAQS.

Table 4-4. MERP Based Estimated O₃ Project Impact (Worst-Case Load)

Precursor	Precursor Emissions ^A (tpy)	8-Hour O ₃ MERP ^B (tpy)
VOC	357	1,049
NO _x	2,049	184
MERP Critical Threshold (ppb)		1
Project % of MERP		1148%
Project O ₃ (ppb)		11

^A The listed precursor emissions are the worst-case project emissions listed in Table 2-1.

^B The listed MERP is from EPA's draft *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier I Demonstration Tool for Ozone and PM_{2.5} under the PSD Permitting Program* (EPA 454/R-16-006), Table 7.1 for the western US.

Table 4-5. MERP Based Estimated O₃ Project Impact (Full Load)

Precursor	Precursor Emissions^A (tpy)	8-Hour O₃ MERP^B (tpy)
VOC	345	1,049
NO _x	863	184
MERP Critical Threshold (ppb)		1
Project % of MERP		502%
Project O₃ (ppb)		5

^A The listed precursor emissions are the worst-case project emissions listed in Table 2-1.

^B The listed MERP is from EPA's draft *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier I Demonstration Tool for Ozone and PM_{2.5} under the PSD Permitting Program* (EPA 454/R-16-006), Table 7.1 for the western US.

5. PSD CLASS I AREA ANALYSIS

The 1977 Clean Air Act Amendments give the Federal Land Managers (FLMs) an “affirmative responsibility” to protect the natural and cultural resources of Class I areas from the adverse impacts of air pollution. The FLM responsibilities include the review of air permit applications to ensure that emissions from the proposed source will not cause or contribute to adverse impacts on the AQRVs of a Class I area.

The U.S. EPA has historically requested that Class I Area analyses be completed if the distance between a proposed PSD project and a Class I Area is approximately 300 km or less. There is not a Class 1 Area within 300 km of the proposed site. Therefore, a Class I Area analysis is not required.

6. ADDITIONAL IMPACT ANALYSIS

This section discusses the proposed project's impact on the following:

- Class II Visibility,
- Growth,
- Vegetation and soils,
- Environmental Justice, and
- Additional Federal Regulations.

6.1. CLASS II VISIBILITY

Visibility impact analyses in Class II areas can be required to ensure the project does not adversely impact any scenic/important views. Guam does not contain any integral vistas; therefore, there are no site-specific guidelines for a visibility impact analysis for the area.

6.2. GROWTH

The elements of the growth analysis include a projection of the associated industrial, commercial, and residential growth that will occur in the area of impact due to the proposed project, including the potential impact on ambient air due to this growth. The proposed project is intended to replace retiring GPA generating units and will help accommodate planned normal economic and population growth on the island. Little or no additional industrial, commercial, or residential growth is projected as a result of this proposed project. It is expected that most future employees are already residing on Guam and do not represent a significant change in the population. Therefore, negligible growth-related ambient air impacts are expected.

6.3. VEGETATION AND SOILS IMPACTS

The proposed project is located in an area consisting of Guam cobbly clay loam soil. This soil is very shallow and drains well and formed in sediment overlying porous coralline limestone. The vegetation in the area is not cultivated, and is mainly forest. Typically, 5 to 10 percent of the surface is covered with gravel and cobbles. The surface layer is dark reddish brown cobbly clay loam about 5 centimeters thick. The subsoil is dusky red gravelly clay loam about 15 centimeters thick. Limestone is at a depth of 20 centimeters. The soil is poorly suited for subsistence farming. (SCS, 1988).

The U.S. EPA developed the secondary NAAQS in order to protect certain air quality-related values (i.e., soil and vegetation) that were not sufficiently protected by the primary NAAQS. The secondary NAAQS represent ambient air concentrations below which most types of soil and vegetation are unaffected by criteria pollutants. If the predicted ambient air concentrations are less than the secondary NAAQS, it can be presumed that emissions from the proposed sources will not result in harmful effects to either soil or vegetation. The cumulative impact analysis will address the applicable primary and secondary ambient air quality standards.

To address sensitive vegetation, the screening criteria in EPA's report, "A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals" will be relied upon. The EPA report establishes air pollutant concentrations that are generally viewed to be protective of soils and vegetation having significant commercial or recreational value, including agricultural crops (EPA, 1980a). Table 6-1 compares EPA's criteria pollutant screening concentrations for exposure to ambient air concentrations (screening concentrations) to the NAAQS. In some cases, the screening concentrations are more restrictive than the NAAQS. Maximum modeled

concentrations plus background for all applicable pollutants and averaging periods will be compared to the screening concentrations.

Table 6-1. Comparison of Sensitive Vegetation Screening Concentrations to NAAQS

Minimum Reported Level for Vegetation Sensitivity								NAAQS/ SAAQS (µg/m³)	Most Restrictive Concentration (µg/m³)	Source of Most Restrictive Concentration
Pollutant	Averaging Period	Sensitive		Intermediate		Resistant				
		(ppmv)	(µg/m³)	(ppmv)	(µg/m³)	(ppmv)	(µg/m³)			
SO₂	1-hr	0.35	917	--	--	--	--	196	196	NAAQS/SAAQS
	3-hr	0.30	786	0.80	2,096	5.0	13,100	1,300	786	Sensitive Screening
	24-hr	--	--	--	--	--	--	365	365	NAAQS/SAAQS
	Annual	--	--	0.007	18	--	--	80	18	Intermediate Screening
PM₁₀	24-hr	--	--	--	--	--	--	150	150	NAAQS/SAAQS
	Annual	--	--	--	--	--	--	50	50	NAAQS/SAAQS
PM₂.₅	24-hr	--	--	--	--	--	--	35	35	NAAQS/SAAQS
	Annual	--	--	--	--	--	--	12	12	NAAQS/SAAQS
NO₂	1-hr	--	--	--	--	--	--	188	188	NAAQS/SAAQS
	4-hr	2.0	3,760	5.0	9,400	9.0	16,920	--	3,760	Sensitive Screening
	8-hr	2.0	3,760	4.0	7,520	8.0	15,040	--	3,760	Sensitive Screening
	1-month	--	--	0.30	564	--	--	--	564	Intermediate Screening
	Annual	--	--	0.05	94	--	--	70	70	NAAQS/SAAQS
CO	1-hr	--	--	--	--	--	--	10,000	10,000	NAAQS/SAAQS
	8-hr	--	--	--	--	--	--	5,000	5,000	NAAQS/SAAQS
	1-week	1,000	1,144,000	--	--	10,000	11,440,000	--	1,144,000	Sensitive Screening
Fluoride	10-day	--	--	--	0.5	--	--	--	0.50	Intermediate Screening
Beryllium	1-month	--	--	--	0.01	--	--	--	0.01	Intermediate Screening
Lead	3 month	--	--	--	1.5	--	--	0.15	0.15	NAAQS/SAAQS
O₃	1-hr	0.20	392	0.35	687	0.55	1,079	--	392	Sensitive Screening
	4-hr	0.10	196	0.15	294	0.35	687	--	196	Sensitive Screening
	8-hr	0.06	118	0.15	294	0.30	589	137.3	118	Sensitive Screening

Source : EPA, 1980a, Table 3.1

6.4. ENVIRONMENTAL JUSTICE

Executive Order (EO) 12898 provides for federal agencies to identify and address disproportionately high and adverse effects of their actions on minority, low-income, and tribal populations. The EPA defines Environmental Justice (EJ) to include the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income in environmental decisions that affect them. Consistent with the Agency's commitment to EJ, as part of the permit review process and before issuing a PSD permit, the Regional Office should examine any superficially plausible claim that the facility seeking the PSD permit will disproportionately affect a minority, low-income, or tribal community. The PSD permit application will include a qualitative assessment of the ethnicity and socioeconomic status of the areas that will be affected by emissions from the proposed project, based on the results of the latest available U.S. Census (2010), to determine whether the project could have a disproportionate effect on any of these communities.

6.5. ADDITIONAL FEDERAL REQUIREMENTS

In addition to the CAA requirements, there are requirements in four other statutes that sometimes must be met before a source can begin construction and operation under a PSD permit. This section discusses the proposed project's compliance with the following statutes:

- Coastal Zone Management Act,
- National Historic Preservation Act,
- Magnuson-Stevens Fishery Conservation and Management Act, and
- Endangered Species Act.

6.5.1. Coastal Zone Management Act

The Guam Coastal Management Program (GCMP) was established in 1979 through a cooperative agreement between the National Oceanic and Atmospheric Administration and the Bureau of Planning Office of the Governor and draws its authorities from the Coastal Zone Management Act (CZMA) of 1972. The entire island has been designated a "coastal zone" in the context of the Coastal Zone Management Act. Therefore, all the Territory's land and sea areas and all its land uses related planning and regulatory agencies, programs and laws falls within the concern of the program. Information on the effect of this program on federally owned lands can be found under Federal Consistency.

Wärtsilä will support the determinations and findings required under the CZMA by providing a copy of the PSD permit to NOAA and the Bureau of Planning Office and by providing any additional information requested by the agencies.

6.5.2. National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) requires EPA, prior to the issuance of any license (e.g., permit), to take into account the effects of its undertakings on cultural and historic properties. There are no known historic or cultural properties in the immediate project area. However, if an inadvertent discovery of historic properties occurs, appropriate measures would be taken to preserve and protect these resources and no significant impacts would be expected.

6.5.3. Magnuson-Stevens Fishery Conservation and Management Act

Wärtsilä will send a letter to the U.S. Department of Commerce, National Marine Fisheries Service, Pacific Islands Regional Office (NMFS-PIRO) explaining the project and the associated ambient impacts. Although the proposed project is not expected to have a detrimental impact on any essential fish habitat (EFH), further analysis will be conducted if deemed necessary by the NMFS-PIRO. Wärtsilä will provide EPA a copy of the NMFS-PIRO response.

6.5.4. Endangered Species Act

Wärtsilä will send a letter to the Pacific Islands Fish and Wildlife Office (PIFWO) regarding the proposed project's potential to impact endangered or threatened plants or animals. Although the proposed project is not expected to have a detrimental impact on threatened or endangered species in the project vicinity, further analysis will be conducted if deemed necessary by the PIFWO. Wärtsilä will provide EPA a copy of the PIFWO response.

7. REFERENCES

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40 CFR Part 51 – Appendix W. Guideline on Air Quality Models.

Appendix A: EMISSION CALCULATIONS

Appendix Table A-1
Wärtsilä 18V50DF Pollutant Emission Rate Calculations - ULSD

Parameter	Variable	Units	Wärtsilä 18V50DF		Data Source
			100% Load	50% Load	
			Value	Value	
Performance Data					
Mechanical Output	MO	kW _m	17,550	8,792	Supplied by Wärtsilä via 6/28/2017 email to Trinity
	--	HP	23,517	11,781	Converted from KW _m
Generation	G	kW _e	17,164	8,582	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Heat Rate (LHV)	HR _{LHV}	Btu/kW _e -hr	7,732	8,370	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Heat Input (LHV)	HI _{LHV}	MMBtu/hr	132.7	71.8	HR _{LHV} *G/10 ⁶
Heat Input (HHV)	HI _{HHV}	MMBtu/hr	139.3	75.4	HI _{LHV} *1.05
Fuel Heat Content (LHV)	LHV	Btu/lb	18,362	18,362	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Fuel Flow	FF _{lb/hr}	lb/hr	7,228	3,912	HI _{LHV} /(LHV/10 ⁶)
Exhaust Data					
Exhaust Temp	--	°F	375.8	359.6	Converted from °C
	T _{stack}	°R	835.8	819.6	Converted from °F
	--	°C	191	182	Supplied by Wärtsilä via 6/27/2017 and 6/28/2017 emails to Trinity
	--	K	464.15	455.15	Converted from °C
Universal Gas Constant	R	psia-ft ³ /lbmol-R	10.73	10.73	http://en.wikipedia.org/wiki/Gas_constant
Standard Pressure	P _{std}	psia	14.696	14.696	40 CFR Part 60, Appendix A, Method 5
Standard Temperature	T _{std}	K	293.2	293.2	40 CFR Part 60, Appendix A, Method 5
Exhaust Volumetric Flow (actual)	Q _{m3s}	m ³ /s	44.7	24.4	Supplied by Wärtsilä via 6/27/2017 and 6/28/2017 emails to Trinity
	--	acfh	5,682,836	3,102,040	Converted from m ³ /s
	Q _{acfm}	acfm	94,714	51,701	Converted from acfm
Exhaust H ₂ O Content	%H ₂ O	% by Vol	6.61%	6.48%	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Exhaust O ₂ Content	%O ₂	% by Vol	11.75%	12.00%	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Exhaust CO ₂ Content	%CO ₂	% by Vol	5.67%	5.51%	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Dry Exhaust Volumetric Flow	Q _{dry}	dcf/min	88,453	48,350	Q _{acfm} *(1-%H ₂ O)
%O ₂ Dry Basis	%O _{2-Dry}	%	12.58%	12.83%	%O ₂ /(1-%H ₂ O)
%CO ₂ Dry Basis	%CO _{2-Dry}	%	6.07%	5.89%	%CO ₂ /(1-%H ₂ O)
Dry Exhaust Volumetric Flow (Std)	Q _{dry-std}	dscf/min	55,875	31,147	Q _{dry} *(T _{std} /T _{stack})
Dry Exhaust Volumetric Flow (32 °F)	Q _{dry-32F}	Nm ³ /min	1,474	822	Q _{dry} *(273.15/T _{stack})*.3048 ³
Stack Diameter	D _{ft}	ft	5.25	5.25	Converted from meters
	D _m	m	1.60	1.60	Supplied by Wärtsilä via 6/27/2017 email to Trinity
Stack Area	A _{m2}	m ²	2.01	2.01	(π*D _m ²)/4
Stack Velocity	V _{m/sec}	m/sec	22.23	12.14	Q _{m3s} /A _{m2}
	V _{ft/sec}	ft/sec	72.94	39.81	Converted from m/s

Appendix Table A-1
Wärtsilä 18V50DF Pollutant Emission Rate Calculations - ULSD

Parameter	Variable	Units	Wärtsilä 18V50DF		Data Source
			100% Load	50% Load	
			Value	Value	
Emission Rates					
Max Sulfur	FS _{ppm}	ppm	15	15	Proposed Permit Limit
SO ₂ Emission Rates	--	g/s	2.729E-02	1.477E-02	Converted from lb/hr
	M _{SO2}	lb/hr	0.217	0.117	FF _{lb/hr} *(FS _{ppm} /10 ⁶)*(MW _{SO2} /MW _s) (Mass Balance - 100% conversion of fuel S)
SO ₂ Emission Factors	--	lb/MMBtu	0.00155	0.00155	M _{SO2} /HI _{HHV}
SO ₂ Molecular Weight	MW _{SO2}	lb/lbmol	64.1	64.1	http://www.webelements.com/
S Molecular Weight	MW _s	lb/lbmol	32.1	32.1	http://www.webelements.com/
	Q _{S02}	ft ³ /min	0.0344	0.0183	Calculated using Ideal Gas Law [((M _{SO2} /MW _{SO2})*R*T _{stack})/(P _{std} *60)]
	C _{d-S02}	ppmvd	0.39	0.38	(Q _{SO2} /Q _{dry})*10 ⁶
	--	ppmvd @ 15% O ₂	0.28	0.28	C _{d-S02} *((20.9-15)/(20.9-%O _{2-Dry} *100))
PM/PM ₁₀ /PM _{2.5} Stack Conc.	C _{d15-PM10}	mg/Nm ³ @ 15% O ₂	20	30	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-PM10}	mg/Nm ³	28.2	41.0	C _{d15-PM10} *((20.9-%O _{2-dry} *100)/(20.9-15))
PM/PM ₁₀ /PM _{2.5} Emission Rates	M _{PM-g/s}	g/s	6.927E-01	5.618E-01	C _{d-PM10} /1000*Q _{dry-32F} /60
	M _{PM10-lb/hr}	lb/hr	5.50	4.46	Converted from g/s
PM/PM ₁₀ /PM _{2.5} Emission Factors	--	lb/MMBtu	0.0395	0.0592	M _{PM10-lb/hr} /HI _{HHV}
	--	g/kW _m -hr	0.142	0.23	M _{pm10-g/s} * 3600/MO
	--	g/kW _e -hr	0.145	0.236	M _{pm10-g/s} * 3600/G
NO _x as NO ₂ Stack Conc.	C _{d15-NOX}	ppmvd @ 15% O ₂	35	40	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-NOX}	ppmvd	49.3	54.7	C _{d15-NOX} *((20.9-%O _{2-dry} *100)/(20.9-15))
NO ₂ Molecular Weight	MW _{NO2}	lb/lbmol	46.0	46.0	http://www.webelements.com/
NO _x as NO ₂ Emission Rates	M _{NOX-lb/hr}	lb/hr	19.7	12.2	[(C _{d-NOX} *(1-%H ₂ O))*Q _{acfm} /10 ⁶]*P _{std} *MW _{NO2} /(R*T _{stack})*60
	M _{NOX-g/s}	g/s	2.482	1.537	Converted from lb/hr
NO _x as NO ₂ Emission Factors	--	lb/MMBtu	0.141	0.162	M _{NOX-lb/hr} /HI _{HHV}
	--	g/kW _m -hr	0.509	0.629	M _{NOX-g/s} * 3600/MO
	--	g/kW _e -hr	0.521	0.645	M _{NOX-g/s} * 3600/G

Appendix Table A-1
Wärtsilä 18V50DF Pollutant Emission Rate Calculations - ULSD

Parameter	Variable	Units	Wärtsilä 18V50DF		Data Source
			100% Load	50% Load	
			Value	Value	
Emission Rates (Continued)					
CO Stack Conc.	C _{d15-CO}	ppmvd @ 15% O ₂	20	20	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-CO}	ppmvd	28.2	27.4	C _{d15-CO} *((20.9-%O _{2-dry} *100)/(20.9-15))
	CO Molecular Weight	MW _{CO}	lb/lbmol	28.0	28.0
CO Emission Rates	M _{CO-lb/hr}	lb/hr	6.87	3.71	[(C _{d-CO} *(1-%H ₂ O))*Q _{acfm} /10 ⁶]*P _{std} *MW _{CO} /(R*T _{stack})*60
	M _{CO-g/s}	g/s	8.656E-01	4.675E-01	Converted from lb/hr
CO Emission Factors	--	lb/MMBtu	0.0493	0.0492	M _{CO-lb/hr} /HI _{HHV}
	--	g/kW _m -hr	0.178	0.191	M _{CO-g/s} *3600/MO
	--	g/kW _e -hr	0.182	0.196	M _{CO-g/s} *3600/G
VOC (as CH ₄) Stack Conc.	C _{d15-VOC}	ppmvd @ 15% O ₂	40	40	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-VOC}	ppmvd	56.4	54.7	C _{d15-VOC} *((20.9-%O _{2-dry} *100)/(20.9-15))
	VOC (as CH ₄) Molecular Weight	MW _{CH4}	lb/lbmol	16.0	16.0
VOC (as CH ₄) Emission Rates	M _{VOC-lb/hr}	lb/hr	7.87	4.25	[(C _{d-VOC} *(1-%H ₂ O))*Q _{acfm} /10 ⁶]*P _{std} *MW _{CH4} /(R*T _{stack})*60
	M _{VOC-g/s}	g/s	9.916E-01	5.355E-01	Converted from lb/hr
VOC (as CH ₄) Emission Factors	--	lb/MMBtu	0.0565	0.0564	M _{VOC-lb/hr} /HI _{HHV}
	--	g/kW _m -hr	0.203	0.219	M _{VOC-g/s} *3600/MO
	--	g/kW _e -hr	0.208	0.225	M _{VOC-g/s} *3600/G
NH ₃ Slip	C _{d15-NH3}	ppmvd @ 15% O ₂	10	10	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-NH3}	ppmvd	14.1	13.7	C _{d15-NH3} *((20.9-%O _{2-Dry} *100)/(20.9-15))
	NH ₃ Molecular Weight	MW _{NH3}	lb/lbmol	17.0	17.0
NH ₃ Emission Rate	M _{NH3-lb/hr}	lb/hr	2.09	1.13	[(C _{d-NH3} *(1-%H ₂ O))*Q _{acfm} /10 ⁶]*P _{std} *MW _{NH3} /(R*T _{stack})*60
	M _{NH3-g/s}	g/s	2.633E-01	1.424E-01	Converted from lb/hr
Fluorides	EF _{Fl}	lb/MMBtu	2.487E-04	2.487E-04	AP-42, Section 1.3, Table 1.3-11 for No. 6 Fuel Oil
	M _{Fl-lb/hr}	lb/hr	3.464E-02	1.875E-02	EF _{Fl} *HI _{HHV}
	M _{Fl-g/s}	g/s	4.365E-03	2.362E-03	Converted from lb/hr

Appendix Table A-2
Wärtsilä 18V50DF H₂SO₄ Emission Rate Calculations

Parameter	Variable	Units	Scenario	Data Source
			100% Load	
SO ₂ Emissions Rate	E _{SO2}	lb/hr	0.217	Per Unit Emission Rate
SO ₂ Molecular Weight	MW _{SO2}	lb/lbmol	64.06	http://www.webelements.com/
H ₂ SO ₄ Molecular Weight	MW _{H2SO4}	lb/lbmol	98.08	http://www.webelements.com/
Fuel Impact Factor (combustion SO ₂ oxidation rate)	F1	--	0.055	EPRI, 2012, Table 6.1, worst-case value
H ₂ SO ₄ manufactured from combustion	H ₂ SO _{4-combustion}	lb/hr	0.0182	Based on Equation 6.4 (EPRI, 2012)
CO catalyst SO ₂ oxidation rate	S3	--	0.35	EPRI, 2012, Page 6-5, average value
H ₂ SO ₄ manufactured from the CO catalyst	H ₂ SO _{4-CO_catalyst}	lb/hr	0.1161	Based on Equation 6.5 (EPRI, 2012)
SCR catalyst SO ₂ oxidation rate	S2	--	0.03	EPRI, 2012, Page 6-5, maximum value
H ₂ SO ₄ manufactured from the SCR catalyst	H ₂ SO _{4-SCR_catalyst}	lb/hr	0.0065	Based on Equation 6.6 (EPRI, 2012)
Total H ₂ SO ₄ manufactured (CSP Application Emission Rate)	EM _{H2SO4}	lb/hr	0.141	H ₂ SO _{4-combustion} + H ₂ SO _{4-CO_catalyst} + H ₂ SO _{4-SCR_catalyst}
	--	tpy	0.618	Converted from lb/hr
	EM _{H2SO4-lbmole}	lbmol/hr	0.0014	EM _{H2SO4} / MW _{H2SO4}
100% of Fuel Sulfur Converted to H ₂ SO ₄	--	lb/hr	0.332	Mass Balance
% of Fuel Sulfur Converted to H ₂ SO ₄	--	--	42.5%	Mass Balance
NH ₃ Slip	E _{NH3}	lb/hr	2.09	Per Unit Emission Rate
NH ₃ Molecular Weight	MW _{NH3}	lb/lbmol	17.03	http://www.webelements.com/
	E _{NH3-lbmole}	lbmol/hr	0.123	E _{NH3} / MW _{NH3}
Net H ₂ SO ₄ Emissions (NH ₃ exceeds H ₂ SO ₄ emissions, therefore, 100% of the H ₂ SO ₄ could be converted to ammonium sulfate)	E _{H2SO4-lbmole}	lbmol/hr	-0.121	EM _{H2SO4-lbmole} - E _{NH3-lbmole} - The residual NH ₃ from the SCR (NH ₃ Slip) can react with the H ₂ SO ₄ to form ammonium sulfate (Page 4-12, EPRI, 2012)

Source: *Estimating Total Sulfuric Acid Emissions from Stationary Power Plants*, Electrical Power Research Institute (EPRI) Product ID: 1023790, dated March 2012 (<http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001023790>). The CSP application emission rate calculations above are based on: (a) worst-case combustion and SCR catalyst oxidation rates, (b) an average CO catalyst oxidation rate, and (c) do not account for the potential reduction in H₂SO₄ emissions due to possible reactions with NH₃ slip.

Appendix Table A-3
Wärtsilä 18V50DF Startup Emission Rates - ULSD

Cold Start¹							
Time (min.)	Operating Mode	Emissions (lb)					
		SO₂	NO_x	CO	PM	PM₁₀/PM_{2.5}	VOC
1 - 30	Startup	0.1083	249.90	4.40	4.40	4.40	6.40
31 - 60	Normal (Worst-case load)	0.1083	9.85	3.44	2.75	2.75	3.94
Total	(lb/hr)	0.2166	259.8	7.84	7.15	7.15	10.34
	(g/s)	2.729E-02	32.73	0.988	9.009E-01	9.009E-01	1.303

¹ A cold catalyst start is when the temperature of the catalyst is close to the ambient temperature.

Warm Start²							
Time (min.)	Operating Mode	Emissions (lb)					
		SO₂	NO_x	CO	PM	PM₁₀/PM_{2.5}	VOC
1 - 30	Startup	0.1083	220.40	2.40	4.40	4.40	5.70
31 - 60	Normal (Worst-case load)	0.1083	9.85	3.44	2.75	2.75	3.94
Total	(lb/hr)	0.2166	230.3	5.84	7.15	7.15	9.64
	(g/s)	2.729E-02	29.01	0.7358	9.009E-01	9.009E-01	1.215

² A warm catalyst start is when the unit is started within 12 hours of shutdown.

Hot Start³							
Time (min.)	Operating Mode	Emissions (lb)					
		SO₂	NO_x	CO	PM	PM₁₀/PM_{2.5}	VOC
1 - 30	Startup	0.1083	209.40	2.40	4.40	4.40	6.40
31 - 60	Normal (Worst-case load)	0.1083	9.85	3.44	2.75	2.75	3.94
Total	(lb/hr)	0.2166	219.3	5.84	7.15	7.15	10.34
	(g/s)	2.729E-02	27.63	0.7358	9.009E-01	9.009E-01	1.303

³ A hot catalyst start is when the unit is started within 6 hours of shutdown and the catalyst temperature is above 100°F.

Per Unit Annual Startup Emissions							
Startup Scenario	Startups Per Day	Emissions (tpy)					
		SO₂	NO_x	CO	PM	PM₁₀/PM_{2.5}	VOC
Cold	1	0.040	47.4	1.43	1.30	1.30	1.89
Warm	1	0.040	42.0	1.07	1.30	1.30	1.76
Hot	1	0.040	40.0	1.07	1.30	1.30	1.89
Total	3	0.119	129.4	3.56	3.91	3.91	5.53

Appendix Table A-4
Wärtsilä 18V50DF GHG Emission Rate Calculations - ULSD

Unit	Heat Input (MMBtu/hr)	Load (MW)	Operating Hours (hrs/yr)	Annual Heat Input (MMBtu/yr)	GHG Pollutant ¹	Emission Factor ² (kg/MMBtu)	Max. Hourly Emissions (kg/hr)	Annual Emissions (metric tpy)	Global Warming Potential ³	Per Unit Total GHG Emissions			Number of Units	Total GHG Emissions		
										CO ₂ e				CO ₂ e		
										(lb/hr)	(metric tpy)	(tpy)		(lb/hr)	(metric tpy)	(tpy)
100% (Base) Load																
Wärtsilä 18V50DF	139.3	17.2	8,760	1,220,268	CO ₂	73.96	10,303	90,251	1	22,713.4	90,251.0	99,484.7	10	227,134.1	902,510.2	994,847.2
					N ₂ O	6.0E-04	8.36E-02	0.732	298	54.9	218.2	240.5		549.1	2,181.8	2,405.1
					CH ₄	3.0E-03	4.18E-01	3.66	25	23.0	91.5	100.9		230.3	915.2	1,008.8
Total CO ₂ e =								22,791.3	90,560.7	99,826.1		227,913.5	905,607.3	998,261.1		
50% of Base Load																
Wärtsilä 18V50DF	75.4	8.6	8,760	660,504	CO ₂	73.96	5,577	48,851	1	12,294.3	48,850.9	53,848.9	10	122,942.6	488,508.8	538,488.7
					N ₂ O	6.0E-04	4.52E-02	0.396	298	29.7	118.1	130.2		297.2	1,181.0	1,301.8
					CH ₄	3.0E-03	2.26E-01	1.98	25	12.5	49.5	54.6		124.7	495.4	546.1
Total CO ₂ e =								12,336.5	49,018.5	54,033.7		123,364.5	490,185.1	540,336.6		

¹ Greenhouse Gas (GHG) pollutants from the Mandatory Greenhouse Gas Reporting rule (40 CFR §98.32).

² Emission factors from the Mandatory Greenhouse Gas Reporting rule (40 CFR Part 98 Subpart C, Tables C-1 and C-2).

³ Global Warming Potentials from the Mandatory Greenhouse Gas Reporting rule (40 CFR Part 98 Subpart A, Table A-1).

Appendix B: NO₂ MODELING TIER 3 JUSTIFICATION

AERMOD (starting with version 16216r) contains the OLM and PVMRM modules as regulatory Tier 3 options for modeling the conversion of NO to NO₂. The inclusion of these elements into AERMOD as regulatory options removes the alternative model approval requirement for OLM and PVMRM. However, the applicant must demonstrate that OLM and PVMRM are applicable on a theoretical basis to the project. The following sections describe how OLM and PVMRM are appropriate for modeling NO₂ concentrations for this project. The Tier 3 analysis will be performed only if necessary.

OZONE LIMITING METHOD TECHNICAL DISCUSSION

The OLM is a detailed screening methodology that accounts for the direct emissions of NO₂ and the conversion of NO into NO₂ in the presence of O₃ once the plume leaves the stack.

Direct NO₂ emissions result from the thermal reaction due to the relatively high exhaust temperatures of the combustion source. After the exhaust exits the stack, the remaining NO reacts with O₃ to form NO₂ and molecular oxygen (O₂) through O₃ titration:



The OLM assumes that at any given receptor location, the amount of NO converted to NO₂ by this reaction is proportional to the O₃ concentration. If the O₃ concentration is less than the NO concentration, the amount of NO₂ formed by this reaction is limited. This condition is commonly referred to as “O₃ limited.” If the O₃ concentration is greater than or equal to the NO concentration, all NO is converted to NO₂ (Cole and Summerhays, 1979).

PLUME VOLUME MOLAR RATIO METHOD TECHNICAL DISCUSSION

The PVMRM is a detailed screening methodology based on O₃ titration (see equation 1 above) that determines the conversion rate of NO to NO₂ as follows. PVMRM:

- Determines the volume of the plume at the receptor. The plume volume calculations use the relative dispersion coefficients that employ the meteorological parameters available in AERMOD and are consistent with the AERMOD’s treatment of dispersion (EPA, 2016).
- Determines the number of moles of NO contained within the plume.
- Determines the number of moles of O₃ in the plume by multiplying the ambient O₃ concentration by the plume volume.
- Calculates the ratio of the number of O₃ moles to the number of NO moles in the plume.
- Calculates the amount of NO converted to NO₂ at the receptor. The modeled NO₂ concentration equals the modeled NO concentration multiplied by the ratio above if the ratio is less than 1 (O₃ limited). Otherwise, 100% of the NO is converted to NO₂.
- Limits the total NO₂ concentration to no more than a user-specified equilibrium ratio of the total NO_x at the receptor. We will use the default equilibrium ratio of 0.90 in the modeling.

OLM AND PVMRM ARE APPLICABLE TO THE PROBLEM ON A THEORETICAL BASIS

This section demonstrates that the O₃ titration mechanism is appropriate and that other mechanisms do not contribute significantly to the overall process of chemical transformation of NO to NO₂ for this study.

In general, the O₃ titration mechanism is responsible for most of the NO to NO₂ conversion (Hanrahan, 1999a). However, there may be site-specific conditions where other mechanisms contribute significantly to the conversion of NO to NO₂. Cole and Summerhays (1979) present a complete discussion of the O₃ titration mechanism. They note two important yet counter-balancing limitations for the O₃ titration mechanism:

- 1) The conversion of NO to NO₂ by peroxy radicals is neglected, which may underestimate the amount of NO₂ produced when the process is O₃ limited, and
- 2) The method ignores photo-dissociation of NO₂ back into NO caused by UV radiation, which may result in an overestimate of converted NO₂ during daylight periods¹⁴.

The conversion of NO to NO₂ by peroxy radicals (RO₂) requires an ample supply of reactive VOCs (represented by RH). The VOCs (RH) react with the hydroxyl radical (OH) to form organic radicals (R) which eventually form RO₂ (CGER, 1991):



These peroxy radicals (RO₂) then react with available NO to form NO₂.

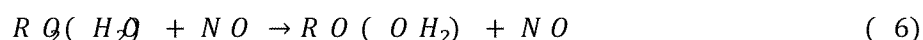
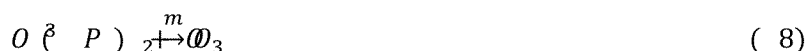
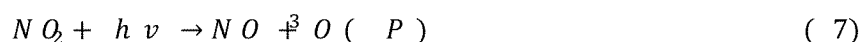


Photo-dissociation of NO₂ back into NO operates in a similar manner. NO₂ can be destroyed by sunlight resulting in NO and a ground state oxygen atom (O(³P)). The ground state oxygen atom then combines with an oxygen molecule to regenerate the O₃ molecule once again.



The O₃ regeneration rate depends on the NO₂ photolysis rate (which is a function of the solar zenith angle) and other factors (CGER, 1991).

Another NO₂ reduction pathway that may be important in Guam involves the photochemical reduction of NO₂ by OH. OH is considered a “detergent of the atmosphere” because it is responsible for the removal of many atmospheric trace gases, including CO, CH₄ and VOCs. The reaction of OH with trace gases is the primary sink mechanism for OH. In areas with a low VOC/NO_x ratio, the NO₂ competes with VOCs for the OH radical which leads to slower peroxy radical production. The slower peroxy radical production means smaller quantities of NO are oxidized to NO₂.

Regions with VOC/NO_x ratios around 8 or higher typically have an ample supply of peroxy radicals (RO₂, HO₂) (CGER, 1991). In these regions, NO can react with peroxy radicals to form NO₂ (see equation 6). On the other hand, in regions with relatively low VOC/NO_x ratios, the radicals used for oxidation of VOCs are instead scavenged by the NO_x, which slows the production of the peroxy radicals and reduces NO_x concentrations (CGER, 1991). The lower concentration of VOCs also results in a lower possible number of peroxy radicals, which lowers the potential rate of NO to NO₂ conversion.

Therefore, the NO and peroxy radical reaction could be an important mechanism for NO₂ formation when all three of the following conditions exist:

1. The region has an ample supply of OH radicals (Andreae and Crutzen, 1997; CGER, 1991),
2. Relatively high VOC concentrations are present (Cole and Summerhays, 1979; CGER, 1991), and
3. The VOC/NO_x ratio is around 8 or higher (CGER, 1991).

¹⁴ The model output, without any post-model adjustments to account for additional conversion mechanisms, was used in the study.

Condition 3 is not expected in Guam. Therefore, the oxidation of NO by O₃ is the primary pathway for NO₂ formation in the atmosphere in Guam. Thus, the model (OLM and PVMRM) is applicable to the problem on a theoretical basis for this site.

PROJECT AREA IS OZONE LIMITED

There are no active ambient air quality monitors on Guam. The closest EPA air quality monitors are located in Hawaii. Since both Guam and Hawaii are remote islands in the Pacific Ocean with limited industrial sources, the majority of O₃ in both locations is expected to be from long range transport. DOH's Kapolei AQM station is the only DOH AQM station that collects both O₃ and NO₂. DOH's Kapolei AQM is located adjacent to the main industrial area on the Island of O'ahu. A review of the Kapolei monitoring data available from EPA's AQS Data Mart¹⁵ found that concurrent hourly NO, NO₂, and O₃ data are available from January 1, 2011 to July 19, 2013.

Appendix Table B-1 and Appendix Figure B-1 show the hourly average monitored NO₂/NO_x ratio and O₃ decreases as the hourly average NO_x concentration increases; which is consistent with O₃ limited conditions.

CONCLUSION

The use of OLM and PVMRM is limited to areas in which the primary NO to NO₂ conversion is the O₃ titration mechanism and are O₃ limited. The project area meets both of those conditions. Thus, OLM and PVMRM are appropriate and may be used for modeling the NO₂ concentrations for this project.

Appendix Table B-1. Measured Hourly Average NO₂/NO_x and O₃ at DOH's Kapolei AQM Station

NO _x (ppb)	Number of Hourly Observations ^{A,B}	Hourly Average NO ₂ /NO _x Ratio	Hourly Average O ₃ (ppb)
> 0 - ≤ 20	13,693	0.6303	25.6
> 20 - ≤ 40	304	0.4966	14.0
> 40 - ≤ 60	64	0.3728	11.2
> 60 - ≤ 80	8	0.3442	10.5
> 80	1	0.3138	3.0

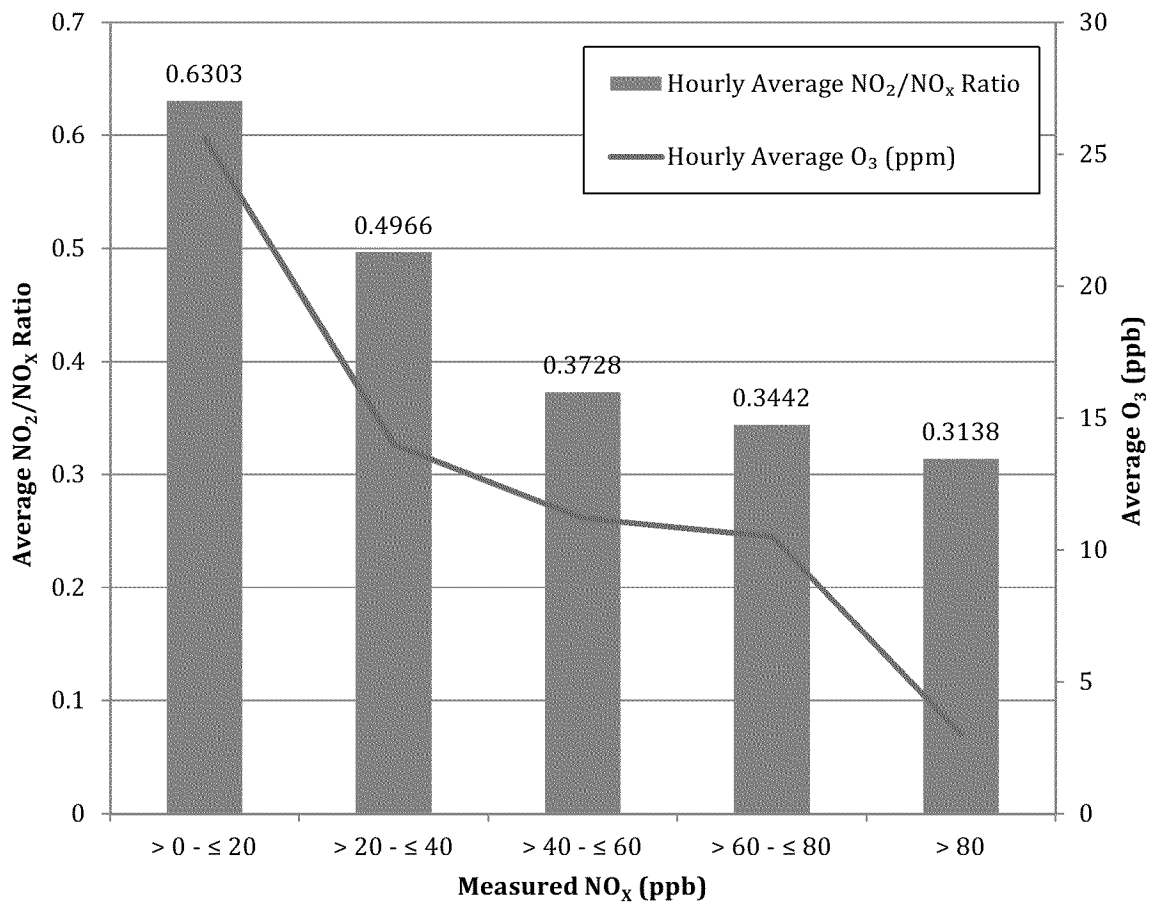
Source: EPA's AQS Data Mart database (<https://aqs.epa.gov/api>)

^A Limited to observations with NO, NO₂, and O₃ > 0 ppb.

^B Data collected between January 1, 2011 - July 19, 2013. Data from hours 07/14/2012 hour 4, 07/15/2012 hour 4, and 07/16/2012 hour 4 were excluded due to irregularities with the reported NO_x and NO concentrations.

¹⁵ <https://aqs.epa.gov/api>

Appendix Figure B-1. Measured Hourly Average NO₂/NO_x and O₃ at DOH's Kapolei AQM Station



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Message

From: Nguyen, Thien Khoi [nguyen.thien@epa.gov]
Sent: 7/10/2020 3:27:50 PM
To: Yannayon, Laura [Yannayon.Laura@epa.gov]; Bohnenkamp, Carol [Bohnenkamp.Carol@epa.gov]; Bohning, Scott [Bohning.Scott@epa.gov]
Subject: RE: Guam Minor Source Baseline date
Attachments: GPA Modeling Protocol v1.0.pdf

Hi Laura/everyone –

That seems consistent with what Trinity Consultants listed as the minor source baseline date for Guam from their modeling protocol in 2018. I attached the full protocol if you want to take a look, but below is a screen shot of the relevant table. I'm not sure if other previous modeling exercises indicated something else, but perhaps Carol or Scott may know of others?

Table 3-4. PSD Baseline and Trigger Dates for Guam

Pollutant	Averaging Periods	Minor Source Baseline Date	Major Source Baseline Date	Trigger Date
NO _x	Annual	1992 ^A	February 8, 1988	February 8, 1988
PM ₁₀	24-hour and Annual	1992 ^A	January 6, 1975	August 7, 1977
PM _{2.5}	24-hour and Annual	2018 ^B	October 20, 2010	October 28, 2011

^A PSD CII 92-01 for the Dededo Generating Station, issued April 16, 1993.

^B This application will be the first PSD application after the PM_{2.5} major source baseline date.

Khoi

From: Yannayon, Laura <Yannayon.Laura@epa.gov>
Sent: Friday, July 10, 2020 8:19 AM
To: Bohnenkamp, Carol <Bohnenkamp.Carol@epa.gov>; Bohning, Scott <Bohning.Scott@epa.gov>
Cc: Nguyen, Thien Khoi <nguyen.thien@epa.gov>
Subject: Guam Minor Source Baseline date

Hi everyone,

I'm wondering if in any previous modeling done for Guam there would be any notes/statement of what the minor source baseline date is for Guam? I've looked at the earliest PSD permit I can find that EPA issued in 1993 and have a Aug. 1, 1992 date as the application complete date. So this is what I believe the minor source baseline date is, but I wanted to check in with you guys to see if we've said it was something else in previous modeling exercises. Please let me know if you have any information on this.

Thanks!

Laura



PREVENTION OF SIGNIFICANT DETERIORATION MODELING PROTOCOL

Proposed New Reciprocating IC Engine Power Plant
Adjacent to Harmon Substation, Guam

Prepared By:

Nancy Matthews – Managing Consultant
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TABLE OF CONTENTS

1. INTRODUCTION	1-1
2. APPLICABILITY OF PREVENTION OF SIGNIFICANT DETERIORATION	2-1
3. AMBIENT IMPACT AND PSD CLASS II INCREMENT MODELING INPUTS	3-1
3.1. Model Selection	3-1
3.2. Project and Existing Emissions	3-2
3.2.1. Project Emissions	3-2
3.2.2. Nearby Sources	3-5
3.3. AERMOD Meteorological Data	3-6
3.4. AERMOD Receptor Data And Modeling Domain	3-11
3.5. Background Concentrations	3-12
3.6. GEP Stack Height and Building Downwash	3-14
3.7. Urban/Rural Classification	3-14
4. AMBIENT IMPACT AND PSD CLASS II INCREMENT MODELING METHODOLOGY	4-1
4.1. Project Impact Analysis	4-1
4.2. PM _{2.5} Impacts	4-3
4.2.1. Preconstruction PM _{2.5} Monitoring Requirements	4-3
4.2.2. PM _{2.5} Ambient Air Quality Analysis	4-3
4.3. Cumulative Impact Analysis	4-4
4.3.1. Ambient Air Quality Modeling Analysis	4-5
4.3.2. PSD Class II Increment Analysis	4-5
4.4. Ozone Analysis	4-5
4.4.1. Preconstruction Ozone Monitoring Requirements	4-6
4.4.2. Ozone Ambient Air Quality Analysis	4-6
5. PSD CLASS I AREA ANALYSIS	5-1
6. ADDITIONAL IMPACT ANALYSIS	6-1
6.1. Class II Visibility	6-1
6.2. Growth	6-1
6.3. Vegetation and Soils Impacts	6-1
6.4. Environmental Justice	6-4
6.5. Additional Federal Requirements	6-4
6.5.1. Coastal Zone Management Act	6-4
6.5.2. National Historic Preservation Act	6-4
6.5.3. Magnuson-Stevens Fishery Conservation and Management Act	6-5
6.5.4. Endangered Species Act	6-5
7. REFERENCES	7-1
APPENDIX A : EMISSION CALCULATIONS	A-1
APPENDIX B : NO ₂ MODELING TIER 3 JUSTIFICATION	B-1

LIST OF FIGURES

Figure 1-1. Proposed Project Location 1-1

Figure 3-1. Project Site and GUM Locations 3-8

Figure 3-2. GUM Wind Rose (2012-2016)..... 3-9

Figure 3-3. Initial Receptor Grid..... 3-12

Figure 3-4. Area Surrounding the Project Site (3-km Radius) 3-16

LIST OF TABLES

Table 2-1. Preliminary Project Emissions.....2-2

Table 3-1. Preliminary Stack Locations.....3-4

Table 3-2. Preliminary Wärtzilä 18V50DF Modeled Stack Parameters and Emission Rates.....3-4

Table 3-3. Point Source Model Emission Inputs for Nearby Sources.....3-5

Table 3-4. PSD Baseline and Trigger Dates for Guam3-6

Table 3-5. GUM Surface Characteristics 3-10

Table 3-6. GUM Meteorological Data Recovery 3-10

Table 3-7. Surface Moisture Determination 3-11

Table 3-8. Classification of Land Use Types 3-15

Table 4-1. PSD Significant Impact Levels and Significant Monitoring Concentrations.....4-2

Table 4-2. MERP Based Estimated Secondary PM_{2.5} (Worst-Case Load).....4-4

Table 4-3. MERP Based Estimated Secondary PM_{2.5} (Full Load).....4-4

Table 4-4. MERP Based Estimated O₃ Project Impact (Worst-Case Load) 4-6

Table 4-5. MERP Based Estimated O₃ Project Impact (Full Load)4-7

Table 6-1. Comparison of Sensitive Vegetation Screening Concentrations to NAAQS.....6-3

1. INTRODUCTION

This protocol is submitted to the United States Environmental Protection Agency (EPA) Region 9 to describe the procedures proposed to be used in an application for a Prevention of Significant Deterioration (PSD) permit for a new 180 megawatt (MW, nominal) power plant to be constructed by Wärtsilä Development & Financial Services, Inc. (Wärtsilä) for Guam Power Authority (GPA). The proposed project would be located on the northern edge of Tamuning, Guam. Figure 1-1 shows the proposed project location.

Wärtsilä proposes to install and operate ten Wärtsilä reciprocating internal combustion engine (RICE) generators in a Flexicycle configuration. Each engine will be equipped with a waste heat recovery steam generator, and the plant will have a single steam turbine with condenser. The ICEs will be cooled with closed loop radiators; the steam cycle will use either wet or dry cooling. If wet cooling is selected, the project equipment will include cooling towers.

The Wärtsilä generators are four-stroke compression ignition engines that will initially be fueled with diesel with a maximum sulfur content of 15 ppm. GPA expects that liquefied natural gas (LNG) will eventually be available in Guam, and at that time the engines would be fueled with LNG.

Figure 1-1. Proposed Project Location



This protocol addresses the PSD Class I and Class II air quality modeling methodology for the proposed project. The methodology described in this protocol is consistent with the EPA guidelines including “Appendix W to Part 51 – Guideline on Air Quality Models” (*Guideline*).

Key components of this protocol include:

- Preliminary estimates of project emissions;
- Proposed modeling procedures for the project:
 - AERMOD will be used to determine the project’s ambient impact, PSD Class II Increment consumption, and ambient impact on soils and vegetation;
 - National Weather Service (NWS) data will be used as input into AERMOD;
 - Ozone monitoring data collected by the Hawaii Department of Health at Sand Island will define the background ozone concentrations;
 - Background concentrations of pollutants for which modeled impacts exceed significant impact levels (expected to be NO₂, PM₁₀ and PM_{2.5}) will be determined by modeling emissions from existing permitted sources within 10 km of the of the proposed project site, plus the Piti/Cabras power plant. Due to the inherent conservatism of EPA guideline models, this approach is expected to provide conservatively high background concentrations for the project area. Background conditions will be verified by limited preconstruction monitoring that will be carried out in parallel with the permitting process; and
- Proposed methods to complete the Additional Impact Analysis.

2. APPLICABILITY OF PREVENTION OF SIGNIFICANT DETERIORATION

The PSD regulations (Title 40, Code of Federal Regulations, Part 52, Section 21 (40 CFR §52.21) define a major stationary source as:

- Any source belonging to a list of 28 source categories which emits or has the potential to emit 100 tons per year (tpy) or more of any pollutant regulated under the Clean Air Act, or
- Any other source which emits or has the potential to emit such pollutants in amounts equal to or greater than 250 tpy.

Guam is designated as either attainment or unclassifiable for all of the National Ambient Air Quality Standards (NAAQS) for all pollutants except for SO₂. Therefore, a PSD review is required for all pollutants with project emissions above the PSD significance level. Table 2-1 shows the proposed project is expected to be subject to PSD review for:

- CO (carbon monoxide),
- NO_x (nitrogen oxides),
- O₃ (ozone) (due to precursors VOC (volatile organic compounds) and NO_x),
- PM (particulate matter)¹,
- PM₁₀ (particles with an aerodynamic diameter less than or equal to 10 micrometers)²,
- PM_{2.5} (particles with an aerodynamic diameter less than or equal to 2.5 micrometers)², and
- Greenhouse Gases (GHGs).

If the wet cooling option is selected, PM₁₀/PM_{2.5} emissions from the cooling tower will also be included in the evaluation of project emissions and ambient impacts.

¹ All particulate matter emitted from the proposed engines is assumed to be in the PM_{2.5} size range. Therefore, PM emissions will be equivalent to directly emitted PM₁₀ emissions and PM will not be discussed further.

² PM_{2.5} emissions and PM₁₀ emissions include gaseous emissions from a source or activity, which condense to form particulate matter at ambient temperatures. On or after January 1, 2011, such condensable particulate matter must be accounted for in applicability determinations and in establishing emissions limitations for PM_{2.5} and PM₁₀ in PSD permits (40 CFR §52.21(b)(50)(i)(a)).

Table 2-1. Preliminary Project Emissions

Pollutant	Scenario	Unit 1, 2, 3, 4, 5, 6, 7 8, 9 or 10 ^{A,B}		Number of Units	Total Project Emissions ^B (tpy)	PSD Significant Level ^C (tpy)	Significant Increase (Yes/No)
		(lb/hr)	(tpy)				
SO ₂	Normal	0.22	0.83	10	8.3		
	Startup	0.22	0.12	10	1.2		
	Total		0.95		9.5	40	No
CO	Normal	6.9	26.3	10	263		
	Startup	7.8	3.6	10	36		
	Total		29.9		299	100	Yes
NO _x	Normal	19.7	75.5	10	755		
	Startup	259.8	129.4	10	1294		
	Total		204.9		2,049	40	Yes
PM	Normal	5.5	21.1	10	211		
	Startup	7.2	3.9	10	39		
	Total		25.0		250	25	Yes
PM ₁₀ ^D	Normal	5.5	21.1	10	211		
	Startup	7.2	3.9	10	39		
	Total		25.0		250	15	Yes
PM _{2.5} ^{D,E}	Normal	5.5	21.1	10	211		
	Startup	7.2	3.9	10	39		
	Total		25.0		250	10	Yes
VOC	Normal	7.9	30.2	10	302		
	Startup	10.3	5.5	10	55		
	Total		35.7		357		
O ₃ ^F	(NO _x)			10	2,049	40	Yes
	(VOC)			10	357	40	
Lead		0.002	0.009	10	0.09	0.6	No
Fluorides		0.035	0.152	10	1.52	3	No
Sulfuric Acid Mist (H ₂ SO ₄)		0.141	0.618	10	6.18	7	No
Hydrogen Sulfide (H ₂ S)		Not Expected		10	--	10	No
Total Reduced Sulfur (TRS)		Not Expected		10	--	10	No
Reduced Sulfur Compounds		Not Expected		10	--	10	No
MWC Organics		Not Expected		10	--	3.5E-06	No
MWC Metals		Not Expected		10	--	15	No
MWC Acid Gases		Not Expected		10	--	40	No
CO ₂ e		22,791	99,826	10	998,261	75,000	Yes

^A See Appendix A for the emission calculations.

^B The listed project emissions (i.e., short-term emissions) represent the project's potential to emit (PTE) emissions. Annual tpy values are based on each unit operating 21 hours per day at normal conditions and 3 hours per day in startup mode.

^C Non-GHG significant levels from 40 CFR §52.21(b)(23)(i). GHG (i.e., CO₂e) significant level from 40 CFR §52.21(b)(49)(iv).

^D Per 40 CFR §52.21(b)(50)(i)(a) PM_{2.5} emissions and PM₁₀ emissions shall include gaseous emissions from a source or activity which condense to form particulate matter at ambient temperatures. On or after January 1, 2011, such condensable particulate matter shall be accounted for in applicability determinations and in establishing emissions limitations for PM_{2.5} and PM₁₀ in PSD permits.

^E In addition to the 10 tpy significant level for direct PM_{2.5} emissions, the project is significant for PM_{2.5} if SO₂ or NO_x emissions exceed 40 tpy (40 CFR §52.21(b)(23)(i)).

^F The project is significant for O₃ if NO_x or VOC emissions exceed 40 tpy (40 CFR §52.21(b)(23)(i)).

3. AMBIENT IMPACT AND PSD CLASS II INCREMENT MODELING INPUTS

All modeling will be performed in compliance with EPA guidance, including the *Guideline*.

3.1. MODEL SELECTION

EPA's recommended dispersion model, AERMOD (version 18081), will be used in the modeling analysis. AERMOD is a steady-state plume model capable of modeling simple, intermediate, and complex terrain receptors. In the stable boundary layer (nighttime), it assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer (daytime) the probability density function describing the horizontal distribution is assumed to be Gaussian, while the vertical distribution is assumed to be bi-Gaussian. AERMOD also contains the PRIME algorithm which incorporates the two fundamental features associated with building downwash: (1) enhanced plume dispersion coefficients due to the turbulent wake, and (2) reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake (EPA, 2018a and EPA, 2018d).

The modeling will be conducted using AERMOD's regulatory default options. The NO₂ modeling will follow the three tier NO₂ modeling approach for the conversion of nitric oxide (NO) to NO₂ described in the *Guideline* (Section 4.2.3.4). The three tiers are:

- Tier 1 – Assume total conversion of NO to NO₂.
- Tier 2 – Use the Ambient Ratio Method 2 (ARM2), which multiplies the modeled NO_x impacts by estimates of representative NO₂/NO_x equilibrium ratios based on ambient levels of NO₂ and NO_x. The national default for ARM2 includes a minimum ambient NO₂/NO_x ratio of 0.5 and a maximum ambient ratio of 0.9. An alternative minimum ambient NO₂/NO_x ratio based on the source specific in-stack NO₂/NO_x ratios will be used in the modeling study. The source specific in-stack NO₂/NO_x ratios are discussed in Section 3.2.1. The project impact modeling will use ARM2. The cumulative impact modeling will use ARM2, provided the Tier 3 method is not required.
- Tier 3 – Perform a detailed screening analysis on a case-by-case basis. EPA has implemented two Tier 3 options, Ozone Limiting Method (OLM) and Plume Volume Molar Ratio Method (PVMRM), into AERMOD as regulatory options. Appendix B contains the demonstration that OLM and PVMRM are appropriate for this project. Both OLM and PVMRM require representative source specific in-stack NO₂/NO_x ratios and background O₃ concentrations. The source specific in-stack NO₂/NO_x ratios are discussed in Section 3.2.1. The representative background O₃ concentrations are discussed in Section 3.5.

AERMOD (starting with version 11059) is capable of calculating the distribution of daily maximum 1-hour values. The daily maximum 1-hour values are calculated when the pollutant ID is either "SO₂" or "NO₂" and the only short-term averaging period specified is "1-hour." When modeling with 5 years of NWS meteorological data, the receptor-by-receptor 5-year average serves as an unbiased estimate of the 3-year average for comparison to the 1-hour SO₂, 1-hour NO₂, and 24-hour PM_{2.5} National Ambient Air Quality Standard (NAAQS) (EPA, 2010b; EPA, 2010c; EPA, 2014).

Controlling modeled concentrations for the percentile based 1-hour SO₂, 1-hour NO₂, and 24-hour PM_{2.5} NAAQS are described below:

- The 1-hour SO₂ NAAQS controlling modeled concentration is the 99th percentile (4th high for one year) daily maximum 1-hour average SO₂ concentration.
- The 1-hour NO₂ NAAQS controlling modeled concentration is the 98th percentile (8th high for one year) daily maximum 1-hour average NO₂ concentration.

- The 24-hour PM_{2.5} NAAQS controlling modeled concentration is the 98th percentile (8th high for one year) daily PM_{2.5} concentration.

For comparison to the NAAQS, the background concentrations described in Section 3.5 will be added to the controlling modeled concentrations.

3.2. PROJECT AND EXISTING EMISSIONS

3.2.1. Project Emissions

The project is comprised of ten Wärtsilä 18V50DF generating units. Table 3-1 lists the approximate UTM coordinates of the proposed stacks. The *Guideline* (Section 8.2.2.d) requires changes in operating conditions that affect the physical emission parameters (e.g., release height, initial plume volume, and exit velocity) of the project sources be considered to ensure that maximum project impacts are determined. Therefore, stack parameters and emissions were developed for full load, minimum load, and startup. Table 3-2 lists the modeled emission rates and stack parameters for the proposed units. Wärtsilä proposes to locate multiple stacks within one (1) diameter of each other in order to enhance plume rise.

The plumes from multiple closely-spaced stacks merge, enhancing plume rise. AERMOD does not explicitly account for this enhanced plume rise. However, the use of a pseudo stack diameter in AERMOD based on the total volume flow rate of the stacks will account for the enhanced plume rise. EPA has allowed this technique on a case-by-case basis.³ The judgement as to whether combining flows is appropriate includes:

- Stack locations – Only stacks located within 1 diameter of each other will be treated as a merged source.
- Stack height and diameter – All of the stacks treated as a merged source will have the same stack height and diameter.
- Stack emission parameters (temperature, momentum or volume flow, emission rates, etc.) - All of the stacks treated as a merged source will have the same emission parameters.

The PSD regulations (40 CFR 51.118(a) and 40 CFR 52.21(h)) contain limits on the use of other dispersion techniques. Dispersion techniques are defined in 40 CFR 51.100(hh)(1) as “any technique which attempts to affect the concentration of a pollutant in the ambient air by...increasing final exhaust gas plume rise by... selective handling of exhaust gas streams so as to increase the exhaust gas plume rise.” However, 40 CFR 51.100(hh)(2) exempts the merging of exhaust gas streams when the facility is originally designed and constructed with merged gas streams. The proposed grouping of the stacks is designed to take advantage of the merged plume effects.

During startup, the unit is expected to reach full load within 5 minutes of the initial firing. The SCR and oxidation catalyst systems become fully functional once the respective catalyst reaches the operating temperature, within approximately 30 minutes following initiation of fuel flow. The time for each catalyst to reach the operating temperature is dependent on how long the unit was shut down. The oxidation catalysts reach their operating temperature before the SCR catalysts. Startup emissions were provided for the following scenarios:

- Cold Startup – when the catalyst temperature is close to ambient temperature. Cold starts are expected after overhaul periods or when the engine has not been operated during the last 1-2 days.
- Warm Startup – when the catalyst temperature is above ambient but less than 100 °C. Warm starts are expected after the engine has not been operated for 12 hours, but less than 24 hours.

³ Model Clearinghouse Information Storage and Retrieval System Record Details - OH GM Defiance Bubble (97-V-02)

- Hot Startup – when the catalyst temperature is greater than 100 °C. Hot starts are expected after the engine has been operated within the previous 12 hours.

The short-term startup emissions listed in Table 3-2 are based on the worst-case startup scenario (cold catalysts). The long-term startup emissions listed in Table 3-2 are based the worst-case combination of 3 startups per day (1 cold startup, 1 warm startup, and 1 hot startup). Unit shutdowns occur very quickly and emissions greater than normal levels during shutdowns are not expected. Appendix A contains the emission rate calculations.

The source specific NO₂/NO_x in-stack ratio for the proposed units will be based on data from recent PSD permits for similar units and EPA's NO₂/NO_x In-Stack Ratio (ISR) Database.⁴ The following summarizes the measured NO₂/NO_x in-stack ratios for diesel engines with a displacement of greater than 30 liters per cylinder:

- Dutch Harbor Power Plant tested a Wärtsilä Model 12V32C DEG. EPA's ISR Database lists a NO₂/NO_x in-stack ratio of 5.52% at 50% load.
- Dutch Harbor Power Plant tested a Caterpillar C-280 DEG. EPA's ISR Database lists a NO₂/NO_x in-stack ratio of 4.5% at 100% load.
- Tor Viking II tested a MaK/6M32 (rated at 3,784 hp) main propulsion diesel engine equipped with SCR and diesel oxidation catalyst. EPA's Alpha⁵ ISR Database lists NO₂/NO_x in-stack ratios for 30%, 40%, 60%, and 80% loads ranging from 4.24% to 15.93%. Of the 7 tests listed, only one had an in-stack ratio greater than 15%.
- Tor Viking II tested a MaK/8M32 (rated at 5,046 hp) main propulsion diesel engine equipped with SCR and diesel oxidation catalyst. EPA's Alpha⁵ ISR Database lists NO₂/NO_x in-stack ratios for 30%, 40%, and 80% loads ranging from 4.71% to 9.27%.
- Vladimir Ignatuk tested a Stork/8TM410 (rated at 5,720 hp) main propulsion diesel engine. EPA's Alpha⁵ ISR Database lists NO₂/NO_x in-stack ratios for 40%, 60%, and 80% loads ranging from 8.16% to 14.79%.

In addition to the above test data, the PSD permitting of six Wärtsilä Model 20V34DF reciprocating engines at the Hawaiian Electric Company Schofield Generating Station (Covered Source Permit No. 0793-01-C, issued September 6, 2016) relied on a 15% NO₂/NO_x in-stack ratio in the Ambient Impact Analysis.

The data from these units support the use a source specific NO₂/NO_x in-stack ratio of 10% for the startup scenario (when the SCR catalyst is not yet at operating temperature), and 15% for the full load and minimum load scenarios, as conservatively high estimates for the proposed units.

If the project design includes a cooling tower, the cooling tower will be modeled as a series of point sources, with associated diameter, exit temperature, and exit velocity. Downwash effects from the cooling tower structure will be evaluated. Particulate emissions from the cooling tower will be calculated using the design water circulation rate, the guaranteed drift rate and the maximum Total Dissolved Solids (TDS) content of the cooling water. Potential emissions of PM₁₀ and PM_{2.5} will be determined using the techniques developed by Reisman and Frisbie⁶ and detailed in a New Mexico Environment Department Air Quality Bureau Technical Memo⁷

⁴ <https://www.epa.gov/scram/nitrogen-dioxidenitrogen-oxide-stack-ratio-isr-database>

⁵ The data listed in the "Alpha" database does not satisfy the requirements of EPA's formal collection effort.

⁶ Calculating Realistic PM₁₀ Emissions from Cooling Towers, Abstract No. 216 Session No. AS-1b, J. Reisman and G. Frisbie, Greystone Environmental Consultants, Inc.

⁷ New Mexico Environment Department, Air Quality Bureau, Technical Memorandum: Calculating TSP, PM-10 and PM-2.5 from Cooling Towers, September 9, 2013. Available at <https://www.env.nm.gov/aqb/permit/documents/PermittingGuidanceforCoolingTowerParticulateEmissions.pdf>

Table 3-1. Preliminary Stack Locations

NAD 83 - Zone 55				
Unit	UTM Coordinates		Base Elevation ^A	
	Easting (m)	Northing (m)	(ft)	(m)
1	263725.5	1496552.5	258.0	78.63
2	263728.5	1496554.0	258.8	78.87
3	263731.5	1496555.5	259.5	79.09
4	263727.5	1496548.5	257.5	78.48
5	263730.5	1496550.0	258.4	78.76
6	263733.5	1496551.5	259.4	79.06
7	263749.5	1496505.5	255.3	77.83
8	263752.0	1496506.5	256.0	78.03
9	263751.0	1496502.0	255.2	77.80
10	263753.5	1496503.0	256.0	78.03

^A Base elevations obtained from AERMAP

Table 3-2. Preliminary Wärtsilä 18V50DF Modeled Stack Parameters and Emission Rates

Load	Stack Parameters ^A							Modeled Emissions (g/s) ^A						NO ₂ /NO _x
	Diameter		Height		Flow	Velocity	Temp.	SO ₂	NO _x		CO	PM ₁₀ /PM _{2.5}		In-Stack
	(ft)	(m)	(ft)	(m)	(m ³ /s)	(m/s)	(K)		Short-Term	Long-Term		Short-Term	Long-Term	Ratio ^B
Three (3) Plumes Merged														
100%	9.09	2.77	131	40.00	134.10	22.23	464.15	8.187E-02	7.446	7.446	2.597	2.078	2.078	15%
50%	9.09	2.77	131	40.00	73.20	12.14	455.15	4.431E-02	4.611	4.611	1.403	1.685	1.685	15%
Startup ^C	9.09	2.77	131	40.00	177.15	29.37	613.15	8.187E-02	98.19	17.685	2.964	2.156	2.157	10%
Two (2) Plumes Merged														
100%	7.42	2.26	131	40.00	89.40	22.23	464.15	5.458E-02	4.964	4.964	1.731	1.385	1.385	15%
50%	7.42	2.26	131	40.00	48.80	12.14	455.15	2.954E-02	3.074	3.074	0.935	1.124	1.124	15%
Startup ^C	7.42	2.26	131	40.00	118.10	29.37	613.15	5.458E-02	65.46	11.790	1.976	1.437	1.438	10%

^A See Appendix A for data sources and supporting calculations. The listed modeled emissions are the total emissions from the multiple units.

^B The source-specific NO₂/NO_x in-stack ratios are discussed in Section 3.2.1.

^C During startup, the units reach the 100% load within 5 minutes of the initial firing. Modeled short-term emissions are conservatively based on all ten (10) units in continuous startup. Modeled long-term emissions are based on 3 startups per day per unit.

3.2.2. Nearby Sources

A cumulative impact analysis is expected to be required for PM₁₀, PM_{2.5}, and NO_x. The *Guideline* (Section 8.3.3) specifies that all sources in the vicinity of the project that are not adequately represented by ambient monitoring background data should be explicitly modeled. Existing sources that cause a significant concentration gradient in the vicinity of the project are not likely to be adequately characterized by the monitored background data. The number of nearby sources to be explicitly modeled in the air quality analysis is expected to be few except in unusual situations.

EPA’s March 1, 2011 memorandum concludes that the most appropriate data to use for compliance demonstrations for the 1-hour NO₂ NAAQS are those based on emissions scenarios that are continuous or frequent enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations. Emergency generators located at commercial facilities (e.g., hotels, hospitals, etc.) are not expected to operate enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations and will not be included in the 1-hour NO₂ modeling. Average hourly emission rates⁸ will be used in place of the maximum hourly emission rates for non-emergency intermittent sources.

The areas with significant concentration gradients from the project are expected to occur within 10 km of the project site. Because no monitoring data are available to represent existing sources on Guam, all permitted sources within 10 km of the project site plus the Piti/Cabras power plant, will be explicitly modeled. Modeled background sources include the existing GPA Dededo, Macheche, and Yigo power plants, which are located within 10 km of the project site. Additional details are provided in Section 3.5.

The *Guideline* (Table 8-2) specifies the emissions input data for NAAQS and PSD increment modeling. The *Guideline* (Table 8-2) allows the model user to account for actual operations in developing the emissions inputs for dispersion modeling of nearby sources.

Table 3-3 lists the emissions input data requirements for nearby sources.

Table 3-3. Point Source Model Emission Inputs for Nearby Sources

Averaging Time	Emissions Limit (lb/MMBtu)	X	Operating Level (MMBtu/hr)	X	Operating Factor (hrs/yr)
Annual & quarterly	Maximum allowable emission limit or federal enforceable permit limit.		Annual level when <i>actually operating</i> , averaged over the most recent 2 years.		<i>Actual operating factor</i> (hours) averaged over the most recent 2 years.
Short term (≤24 hours)	Maximum allowable emission limit or federal enforceable permit limit.		Annual level when <i>actually operating</i> , averaged over the most recent 2 years.		<i>Continuous operation</i> , i.e., all hours of each time period under consideration (8,760 hrs/yr).

Source: Table 8-2 of the Guideline

The “annual level when actually operating, averaged over the most recent 2 years” will be calculated by dividing the average heat input for most recent 2 years available by the average operating hours for the respective

⁸ For example, the average hourly emission rate for a source with an annual operating limit of 500 hours equals the maximum hourly emission rate times 500/8760.

calendar years, if these data are available. If actual heat input data are not available, the analysis will assume full-time, full load operation for non-emergency, non-intermittent units.

The PSD increment evaluation requires the inclusion of all increment-consuming sources. PSD increments have not been established for 1-hour SO₂ and 1-hour NO₂. Table 3-4 lists the PSD baseline and trigger dates for Guam.

Table 3-4. PSD Baseline and Trigger Dates for Guam

Pollutant	Averaging Periods	Minor Source Baseline Date	Major Source Baseline Date	Trigger Date
NO ₂	Annual	1992 ^A	February 8, 1988	February 8, 1988
PM ₁₀	24-hour and Annual	1992 ^A	January 6, 1975	August 7, 1977
PM _{2.5}	24-hour and Annual	2018 ^B	October 20, 2010	October 20, 2011

^A PSD GU 92-01 for the Dededo Generating Station, issued April 16, 1993.

^B This application will be the first PSD application after the PM_{2.5} major source baseline date.

3.3. AERMOD METEOROLOGICAL DATA

AERMOD uses several different boundary layer parameters to model how pollutants disperse in the atmosphere. Many of these parameters are not directly measured, but are calculated from other variables that are more easily measured. AERMET, EPA's meteorological processor for AERMOD, uses observed near-surface wind and temperature and site-specific surface characteristics to estimate these boundary layer parameters (EPA, 2018b). The following surface characteristics are input into AERMET during the stage 3 processing:

- Surface roughness length (z_o) – the height above the ground at which horizontal wind velocity is typically zero,
- Noon-time albedo (r) – the fraction of radiation reflected by the surface, and
- Daytime Bowen ratio (B_o) – the ratio of the sensible heat flux (H) to the latent heat flux (λE).

In the AERMOD Implementation Guide, EPA recommends the following methodology to determine these surface characteristics:

1. *The determination of the surface roughness length should be based on an inverse-distance weighted geometric mean for a default upwind distance of 1 kilometer relative to the measurement site. Surface roughness length may be varied by sector to account for variations in land cover near the measurement site; however, the sector widths should be no smaller than 30 degrees.*
2. *The determination of the Bowen ratio should be based on a simple unweighted geometric mean (i.e., no direction or distance dependency) for a representative domain, with a default domain defined by a 10km by 10km region centered on the measurement site.*
3. *The determination of the albedo should be based on a simple unweighted arithmetic mean (i.e., no direction or distance dependency) for the same representative domain as defined for Bowen ratio, with a default domain defined by a 10km by 10km region centered on the measurement site.*

EPA developed AERSURFACE to calculate the surface characteristics based on this recommended methodology. AERSURFACE reads land cover values from the United States Geological Survey (USGS) 1992 National Land Cover Dataset (NLCD92). However, the NLCD92 is not available for Guam. Therefore, the surface characteristics for the Guam International Airport meteorological station (GUM) were obtained from the EPA's "SO₂ NAAQS Designations Modeling Analyses, Results and Documentation for the Island of Guam" report, dated January 13,

2017.⁹ The surface characteristic values presented in Table 3-5 are based on the Coastal Change Analysis Program (C-CAP) data for the territory of Guam from 2005.¹⁰ As is shown in Figure 3-1, GUM is approximately 5.6 km (3.5 miles) to the south-southwest of the project site.

In the *AERMOD Implementation Guide*, EPA states that the determination of representativeness of NWS meteorological data should include a comparison of surface characteristics of the NWS measurement site and source locations, coupled with a determination of the importance of those differences relative to predicted concentrations (EPA, 2018e).

The project site and GUM are located on the north-central portion of the island. No major geographic features impacting the surface conditions or wind patterns exist between the two locations. Therefore, the meteorological data from GUM are considered representative of the project site.

In the *Guideline*, EPA states that five (5) years of NWS meteorological data are adequate to ensure that worst-case meteorological conditions are represented in the model results. GUM surface and upper air data from January 1, 2012 to December 31, 2016 are proposed.

AERMET (version 18081) will be used to create the required meteorological input files. AERMINUTE (version 15272) was used to calculate the hourly wind speed and direction from the 1-minute and 5-minute Automated Surface Observing System (ASOS) data.¹¹ Run logs of the AERMET and AERMINUTE meteorological data file processing will be provided as part of the final modeling report supporting the PSD permit application. The following AERMET stage 3 processing options will be used:

- > METHOD WIND_DIR RANDOM
- > METHOD UASELECT SUNRISE
- > METHOD STABLEBL ADJ_U*, and
- > THRESH_1MIN 0.5.

Figure 3-2 presents a wind rose of the 5 years of data. The hourly values of wind speed and direction were measured at 10 m (32.8 ft). Table 3-6 shows the GUM meteorological data recovery for the 5-year period. The total percent of calm, variable¹², and missing data (i.e., non-calculable hours) is less than 10%.

Based on EPA's guidance in the AERSURFACE user's guide (EPA, 2008), the surface moisture conditions for each modeled year are based on the annual precipitation for each year compared to the annual precipitation from the 30-year climatological period (1981-2010). The surface moisture is "wet" if the annual precipitation is in the upper 30th percentile, "dry" if the annual precipitation is in the lower 30th percentile, and "average" if the annual precipitation is in the middle 40th percentile of the climatological period. Table 3-7 compares the annual precipitation from each modeled year to the upper 30th, lower 30th, and middle 40th percentiles of the annual precipitation from the 1981-2010 climatological period. The surface moisture conditions were average in 2011 and 2013, dry in 2012, and wet in 2014 and 2015.

⁹ https://www.epa.gov/sites/production/files/2017-01/documents/final_so2_modeling_report_drr_1.13.17.pdf

¹⁰ <https://coast.noaa.gov/ccapftp/>

¹¹ The 1-minute and 5-minute ASOS data were downloaded from the National Centers for Environmental Information (NCEI): <ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/> and <ftp://ftp.ncdc.noaa.gov/pub/data/asos-fivemin/>. Data prior to September 2013 are not available.

¹² The wind direction is reported as variable when the wind direction varies by 60 degrees or more during the 2-minute evaluation period and the 2-minute wind speed is 6 knots or less. Since wind direction is not recorded, AERMOD classifies these hours as missing.

GUM upper air soundings were input into AERMET. Missing upper air soundings from GUM were replaced with the respective soundings from Chuuk International Airport, Micronesia (TKK) which is located approximately 1,000 km to the southeast of GUM.

Figure 3-1. Project Site and GUM Locations



Figure 3-2. GUM Wind Rose (2012-2016)

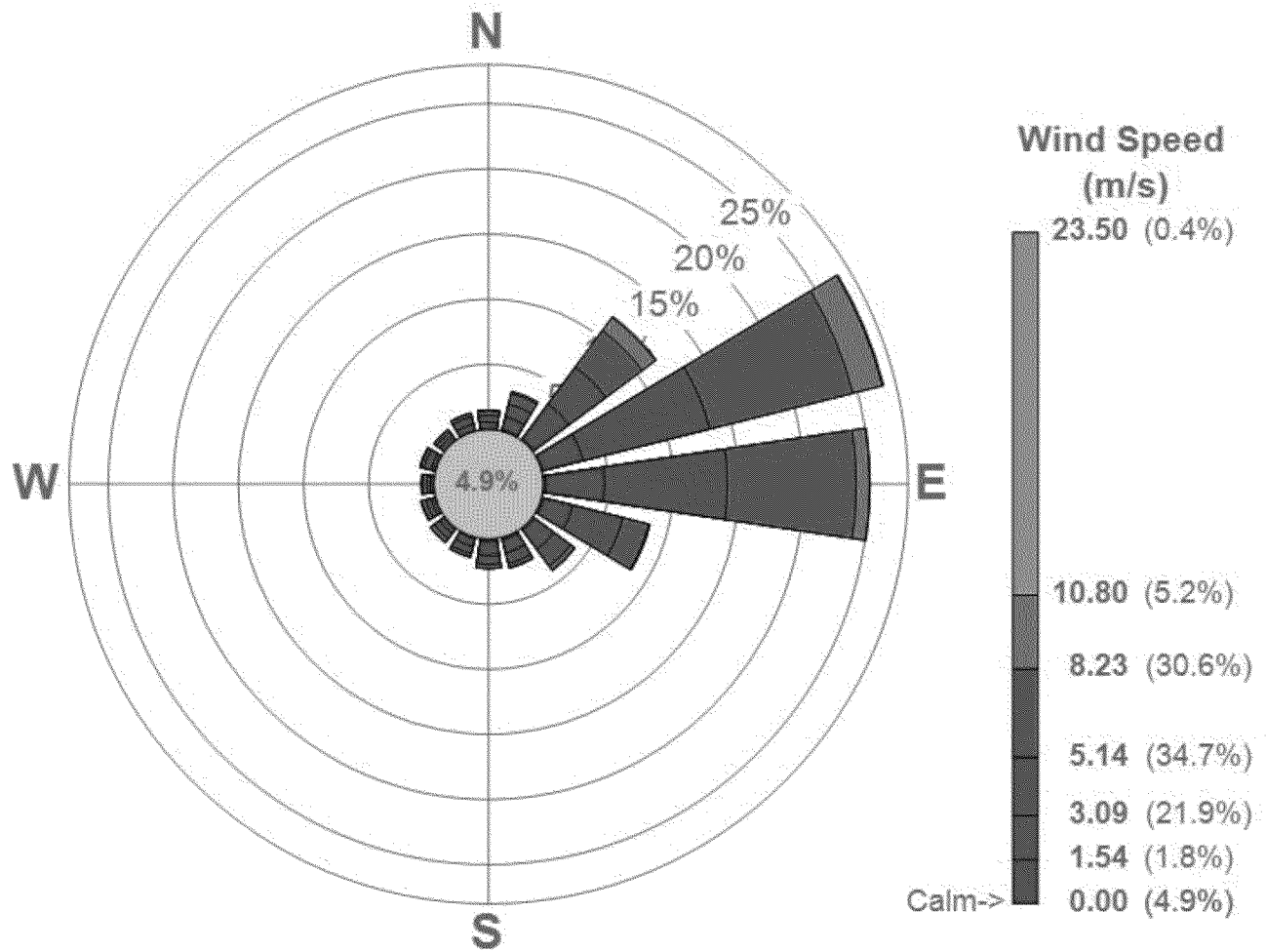


Table 3-5. GUM Surface Characteristics

Surface Roughness						
Sector	Sector Arc (Degrees from North)		Sector Width (Degrees)	Surface Roughness Length (m)	Bowen Ratio	
	Start	End			Wet	Average
1	0	45	45	0.064		
2	45	90	45	0.076		
3	90	135	45	0.142		
4	135	180	45	0.178	0.27	0.37
5	180	225	45	0.156		
6	225	270	45	0.116		
7	270	315	45	0.068		
8	315	360	45	0.061		
						0.14

Source: EPA's "SO₂ NAAQS Designations Modeling Analyses, Results and Documentation for the Island of Guam" report, dated January 13, 2017.

Table 3-6. GUM Meteorological Data Recovery

Year	Hours Processed	Calm Winds ¹		Variable Winds ²		Missing Data ³		Total Non-Calculable	
		Number of Hours	Percent of Period	Number of Hours	Percent of Period	Number of Hours	Percent of Period	Number of Hours	Percent of Period
2012	8,784	726	8.3%	59	0.7%	48	0.5%	833	9.5%
2013	8,760	486	5.5%	37	0.4%	11	0.1%	534	6.1%
2014	8,760	363	4.1%	10	0.1%	1,491	17.0%	1,864	21.3%
2015	8,760	289	3.3%	5	0.1%	1	0.0%	295	3.4%
2016	8,784	273	3.1%	10	0.1%	24	0.3%	307	3.5%
Total	43,848	2,137	4.9%	121	0.3%	1,575	3.6%	3,833	8.7%

¹ Calm hours are when the wind speed and direction are both zero

² Variable wind direction is reported when the wind direction varies by 60 degrees or more during the 2-minute evaluation period and the 2-minute wind speed is 6 knots or less. The wind speed is greater than zero and the wind direction is missing.

³ Missing data are when upper air, cloud cover, temperature, both the wind speed and direction data are missing.

Table 3-7. Surface Moisture Determination

Climatological (1981-2010)			Annual	
Annual Precip. (inch)			Precip.	Wet, Dry
Bottom 30 th %	Top 30 th %	Year	(inch)	Or Average?
88.3	110.7	2012	99.1	Average
		2013	101.6	Average
		2014	118.5	Wet
		2015	115.8	Wet
		2016	94.0	Average

3.4. AERMOD RECEPTOR DATA AND MODELING DOMAIN

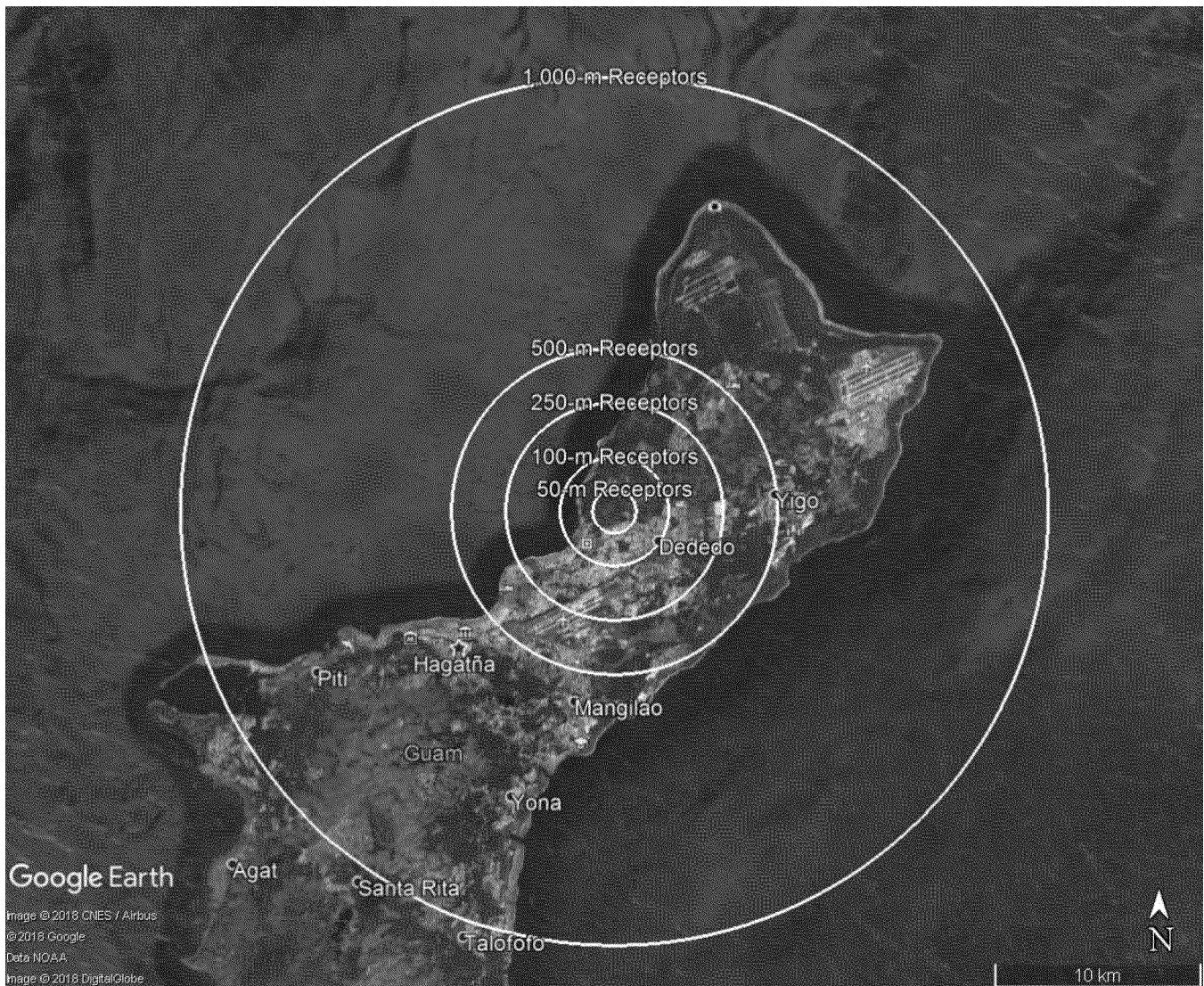
Figure 3-3 shows the initial modeling grid consisting of:

- 25-m spaced receptors along the fence line (i.e., that area to which public access is physically restricted),
- 50-m spaced receptors centered at 263775 m E, 1496525 m N to 1.0 km,
- 100-m spaced receptors from 1.0 km to 2.5 km,
- 250-m spaced receptors from 2.5 km to 5 km,
- 500-m spaced receptors from 5.0 km to 7.5 km, and
- 1,000-m spaced receptors from 7.5 km to 20 km.

Additional receptors will be added as needed to areas of maximum impact to ensure the maximum concentrations are identified.

EPA's AERMAP (version 18081) program will be used to determine the receptor elevations and height scales. AERMOD uses the receptor's height scale to determine if the plume is terrain following or terrain impacting. The AERMAP User's Guide (EPA, 2018c) states that the domain boundary must include all terrain features that exceed a 10% elevation slope from any given receptor. USGS National Elevation Dataset (NED) 1/3 arc-second data covering the entire island of Guam was obtained from the USGS National Map Viewer for input into AERMAP to determine the receptor elevations and height scales. Additional NED 3 arc-second data was included for the over-water receptors located outside the data boundary of the 1/3 arc-second data. The PSD permit application support document will include run logs of the AERMAP receptor data processing.

Figure 3-3. Initial Receptor Grid



3.5. BACKGROUND CONCENTRATIONS

A cumulative impact analysis is required for any pollutant for which the proposed source's estimated ambient pollutant concentrations exceed the modeling significant impact levels (SILs). The project's controlling modeled concentrations are expected to be above the respective modeling SILs for the following:

- 1-hour and annual NO_2 ,
- 24-hour and annual $\text{PM}_{2.5}$, and
- 24-hour and annual PM_{10} .

Therefore, a cumulative impact analysis will be performed for these pollutants and averaging periods. The cumulative impact analysis takes into account all sources affecting the air quality in an area. In this analysis, the project's impact plus background concentrations are combined and compared to the NAAQS. This step requires defining appropriate background concentrations.

Background concentrations include contributions from nearby sources and other sources (e.g., natural, minor, and distant major sources). The contributions from nearby sources will be included by explicitly modeling these sources.

The existing GPA generating units at Piti/Cabras, Dededo, Macheche, and Yigo are the main significant nearby stationary sources and will be included in the modeling. Therefore, ambient monitoring data is needed to define the other sources in the area.

There are no active ambient air quality monitors on Guam. A search of historical data found the following summary from “Guam and CNMI Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement”¹³ prepared for the U.S. Department of the Navy:

The government of Guam has not collected ambient air quality data since 1991. Therefore, no existing ambient air quality data are available to represent current air quality conditions with respect to the criteria pollutants for which the NAAQS were established. Historical data are available from 1972 through 1991, when ambient air quality data were collected at a number of sites through a USEPA-sponsored monitoring program. The monitored pollutants were total suspended particles (TSP), SO₂, NO₂, and nitrogen monoxide (NO). In 1991, PM₁₀ was monitored in addition to TSP.

Prior to 1991, TSP were monitored at 20 sites, SO₂ at 14 sites, NO₂ at five sites, and NO at one site. In 1991, PM₁₀ was monitored at four sites. In addition to the historical monitoring identified above, the GPA established a network of five stations to measure SO₂ at locations that are not downwind or close to any major EGUs during normal trade wind conditions from the fall of 1999 through the summer of 2000...

Because of the lack of current ambient monitoring data, the existing air quality conditions on Guam cannot be evaluated by a direct comparison of the ambient pollutant concentration levels with the NAAQS. Instead, with the exception of O₃ concentrations, the existing air quality conditions around the site will be based on a modeling assessment of permitted stationary sources located within 10 km of the proposed project site plus the Piti/Cabras power plant.

O₃ is a regional pollutant that is not directly emitted into the atmosphere like the other criteria pollutants. O₃ has an appreciable formation time because the mixing of reactants and products occurs over a large volume of air. Since the mixing of O₃ precursors occurs over a large volume of air, the monitoring of small-scale spatial variability is not necessary. The nearest EPA O₃ monitor is located on the Island of Hawaii. Guam and Hawaii are both remote islands in the Pacific Ocean with limited industrial sources. The majority of O₃ in both locations is expected to be from long range transport.

Tier 3 NO₂ modeling requires concurrent hourly O₃ data. The nearest EPA O₃ monitor with concurrent hourly data is located on the Island of Hawaii. The Hawaii Department of Health (DOH) monitors O₃ at the Kapolei and Sand Island AQM stations on the Island of O‘ahu. DOH’s Kapolei AQM station has had periods with less than 75% data recovery. DOH’s Sand Island AQM station is the state’s SLAMS O₃ monitor and is located at the University of Hawai‘i’s Ānuenue Fisheries. This area is composed of light industrial, commercial, recreational, and harbor units and is approximately 1.5 km southwest (typically downwind) of downtown Honolulu.

DOH’s Sand Island AQM station was selected to provide the concurrent hourly O₃ data if needed for Tier 3 NO₂ modeling. Hourly O₃ data were obtained from EPA’s Air Quality System (AQS) Data Mart for the 5-year period (January 1, 2012 through December 31, 2016) of the NWS meteorological data. Missing observations will be filled using the following three step approach:

1. When one or two consecutive hours are missing, interpolation is used to fill these missing values.

¹³ Appendix I - Air Impact Study (www.Guambuildupeis.us/documents)

2. When three or more consecutive hours are missing, the missing values are filled with the maximum concentration from the same hour from the previous and following day.
3. When three or more consecutive hours are missing and both concentrations for the same hour from the previous and following day were missing, missing values are filled with the maximum concentration from the same hour from the entire calendar year.

The use of the maximum hourly concentrations for data gaps greater than two hours is not expected to result in an underestimation of the missing O₃ concentrations.

3.6. GEP STACK HEIGHT AND BUILDING DOWNWASH

For air quality modeling purposes, the proposed new units will be evaluated in terms of their proximity to nearby structures to determine whether stack effluents may be affected by downwash in the turbulent wake of such structures. AERMOD uses the following building parameters to account for downwash:

- BUILDHGT, the building height,
- BUILDWID, the projected width of the building perpendicular to the flow,
- BUILDLEN, the projected length of the building along the flow,
- XBADJ, the along-flow distance from the stack to the center of the upwind face of the projected building, and
- YBADJ, the across-flow distance from the stack to the center of the upwind face of the projected building.

Building parameters will be obtained using EPA's Building Profile Input Program designed for AERMOD (BPIPPRM – version 04274). BPIPPRM calculates the building parameters for 36 wind directions based on the physical dimensions of the structures surrounding a source. Trinity reviewed information from Google Earth and determined that off-site buildings will not need to be included in the modeling. The final modeling report will provide the preliminary structures and heights entered into BPIPPRM and will include the BPIPPRM input and output files.

The *Guideline* states the use of stack heights greater than the Good Engineering Practice (GEP) stack height in the modeling is prohibited (40 CFR §51.118 and 40 CFR §51.164). Per 40 CFR §51.100 the GEP stack height limit for this project is the greater of:

- 65 meters, measured from the ground-level elevation at the base of the stack, or
- The formula GEP stack height ($GEP_f = H + 1.5L$). Where, H is the structure height, and L is the lesser dimension of the structure (height or projected width). The maximum calculated formula GEP stack height from BPIPPRM is 33.05 meters (108.4 ft).

The proposed stack heights of 40 meters (132.5 ft) are expected to be greater than the formula GEP stack height but less than 65 meter limit; consequently, the stack heights are within acceptable limits.

3.7. URBAN/RURAL CLASSIFICATION

The selection of either rural or urban dispersion coefficients in the air quality modeling follows the procedure provided in the *Guideline*. Categorizing an area as urban or rural is determined by land use classification or population. Section 7.2.1.1.b in the *Guideline* specifies that the land use procedure is considered more definitive; therefore, the land use procedure is used to classify the area around the project site for air quality modeling purposes.

The land use is classified within the total area circumscribed by a 3-km radius circle (A_0) about the source, using the land use typing scheme proposed by Auer (1978).

Table 3-8 defines the land use types, where I1, I2, C1, R2, and R3 represent urban environments, while the other categories designate rural characteristics. Thus, if land use types I1, I2, C1, R2, and R3 (urban) account for 50% or more of the circumscribed area, urban dispersion coefficients should be used. Otherwise, appropriate rural dispersion coefficients are used. As shown in Figure 3-4, the urban land use types are less than 50%. Therefore, the area was classified as rural.

Table 3-8. Classification of Land Use Types

Auer Category	Auer Description
I1*	Heavy industrial
I2*	Light-moderate industrial
C1*	Commercial
R1	Common residential
R2*	Compact residential I
R3*	Compact residential II
R4	Estate residential
A1	Metropolitan natural
A2	Agricultural rural
A3	Undeveloped wasteland
A4	Undeveloped rural
A5	Water surfaces

Source: Auer, 1978

* Urban character

Figure 3-4. Area Surrounding the Project Site (3-km Radius)



4. AMBIENT IMPACT AND PSD CLASS II INCREMENT MODELING METHODOLOGY

This section describes the modeling methodology that will be used to demonstrate that the proposed project does not cause or contribute to the violation of any NAAQS or PSD Class II Increment.

Following the guidance contained in the *Guideline* (Section 9.2.3), the modeling will be conducted in two distinct stages:

- Stage 1 – Project Impact Analysis: This stage models only the impact of the new or modifying source.
- Stage 2 – Cumulative Impact Analysis: This stage models the combined impact of the project and nearby sources and includes the background concentration from other sources not modeled (e.g., natural, minor, and distant major sources).

Each stage involves increasing complexity and details, as required, to demonstrate that the project will not cause or contribute to a violation of any NAAQS or PSD increment. If the project impact analysis demonstrates that a source will not cause or contribute to any potential violation, this alleviates the need for a cumulative impact analysis.

4.1. PROJECT IMPACT ANALYSIS

The project impact analysis (stage 1) determines the potential of the project to cause or contribute to a violation of any NAAQS or PSD increment. If screening or refined modeling indicates that the project will not cause or contribute to any potential violation of any NAAQS or PSD increment then the project impact analysis would generally be sufficient for the required demonstration under PSD (The *Guideline*, Section 9.2.3.c). Table 4-1 lists the significant impact levels (SILs) that will be used to determine if the project has the potential to cause or contribute to a violation. A preliminary project impact analysis as described here determined that the project is expected to be significant for:

- 24-hour PM₁₀,
- 24-hour and annual PM_{2.5}, and
- 1-hour NO₂.

A cumulative impact analysis (stage 2) is required for the pollutant averaging periods above a SIL. The receptors that indicate the location of significant ambient impacts will be used to define the modeling domain for use in the cumulative impact analysis (The *Guideline*, Section 9.2.3.c). If a modeled pollutant and averaging period impact is below the modeling SIL, there is no impact area and there will be no sources to include in the NAAQS and PSD increment analysis. Under these circumstances, no cumulative impact analysis would be required and no existing sources would need to be considered in the project impact analysis.

Table 4-1. PSD Significant Impact Levels and Significant Monitoring Concentrations

Pollutant	Averaging Period	Modeling Significant Impact Level (SIL) ($\mu\text{g}/\text{m}^3$)	Significant Monitoring Concentration ^A (SMC) ($\mu\text{g}/\text{m}^3$)
SO ₂	1-hr	7.8 ^B	--
	3-hr	25 ^C	--
	24-hr	5 ^C	13
	Annual	1 ^C	--
PM ₁₀	24-hr	5 ^C	10
	Annual	1 ^C	--
PM _{2.5}	24-hr	1.2 ^D	0
	Annual	0.2 ^D	--
NO ₂	1-hr	7.5 ^E	--
	Annual	1 ^C	14
CO	1-hr	2,000 ^C	--
	8-hr	500 ^C	575
Lead	Quarterly	--	0.1
Fluoride	24-hr	--	0.25
H ₂ S	1-hr	--	0.2
TRS	1-hr	--	10
Reduced Sulfur Compounds	1-hr	--	10

^A The SMCs are codified in 40 CFR §52.21(i)(5)(i).

^B EPA's Stephen D. Page memorandum, dated August 23, 2010, "Guidance Concerning the Implementation of the 1-hour SO₂ NAAQS for the Prevention of Significant Deterioration Program," recommends a 1-hour SO₂ SIL of 3 ppb (7.8 $\mu\text{g}/\text{m}^3$).

^C Table C-4 (page C.28) of the October 1990 Draft New Source Review Workshop Manual lists the SILs for 3-hr, 24-hr, and annual SO₂, 24-hour and annual PM₁₀, annual NO₂, and 1-hour and 8-hour CO.

^D EPA's Stephen D Page memorandum, revised August 18, 2016, draft "Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program," recommends a 24-hour SIL of 1.2 $\mu\text{g}/\text{m}^3$ and an annual SIL of 0.2 $\mu\text{g}/\text{m}^3$.

^E EPA's Stephen D. Page memorandum, dated June 29, 2010, "Guidance Concerning the Implementing the 1-hr NO₂ National Ambient Air Quality Standard in Prevention of Significant Deterioration Permits," recommends a 1-hr NO₂ SIL of 4 ppb (7.5 $\mu\text{g}/\text{m}^3$).

The *Guideline* (Section 8.2.2.d) requires changes in operating conditions that affect the physical emission parameters (e.g., release height, initial plume volume, and exit velocity) of the project sources be considered to ensure that maximum project impacts are determined. Therefore, the project impact analysis will evaluate the units operating at full load, minimum load, and startup. The following steps were used to determine the project's maximum impact for each pollutant and averaging period for the preliminary determination of areas of significant concentration gradients; these steps will also be followed for the final project impact analysis:

1. Determine the project's maximum impact for all receptors for all averaging periods for the three operating scenarios (full load, minimum load, and startup) with all ten units operating simultaneously.
2. Compare the project's maximum impact identified in step 1 with the significant monitoring concentrations (SMC) and modeling SIL. Table 4-1 lists the modeling SILs and SMCs.
3. Compare the project's full load impacts with the modeling SILs.

The maximum impacts from the worst-case load scenario for all PSD regulated pollutants are compared to the SMCs and the SILs. Pollutants with maximum project impacts above the SMC require may require pre-construction ambient air monitoring. Project impacts for PM_{2.5} and O₃ are expected to exceed preconstruction monitoring thresholds, and a preconstruction monitoring plan will be prepared for those pollutants. The project impacts for the other PSD pollutant averaging periods are expected to be below the SMCs.

Pollutants and averaging periods with maximum project impacts above the applicable SIL will require a cumulative impact analysis, which will be included in the final report supporting the PSD permit application. The cumulative impact analysis will be conducted for the worst-case and full design load scenarios.

4.2. PM_{2.5} IMPACTS

4.2.1. Preconstruction PM_{2.5} Monitoring Requirements

As disused in Section 3.5, there are no current ambient PM_{2.5} data for Guam. Wärtsilä will be submitting a preconstruction monitoring protocol to address the collection of preconstruction PM_{2.5} monitoring data.

4.2.2. PM_{2.5} Ambient Air Quality Analysis

The discussion above addressed the project's primary impact which will be determined by AERMOD. However, PM_{2.5} is comprised of both primary PM_{2.5}, which is directly emitted into the air, and secondary PM_{2.5}, which forms indirectly from fuel combustion and other sources. Secondary PM_{2.5} forms in the atmosphere from gases. Some of these reactions require sunlight and/or water vapor. Secondary PM_{2.5} includes:

- Sulfates formed from sulfur dioxide emissions from power plants and industrial facilities;
- Nitrates formed from nitrogen oxide emissions from cars, trucks, and power plants; and
- Carbon formed from reactive organic gas emissions from cars, trucks, industrial facilities, forest fires, and biogenic sources such as trees.

AERMOD is not capable of modeling secondary PM_{2.5}. The *Guideline* (Section 5.3.2) recommends the following two tier approach for assessing single-source secondary PM_{2.5} impacts:

- Tier 1 – The first tier involves use of appropriate and technically credible relationships between emissions and ambient impacts developed from existing modeling studies deemed sufficient for evaluating a project's impact. EPA is in the process of developing Modeled Emission Rates for Precursors (MERPs) as a Tier 1 demonstration tool for secondary PM_{2.5}.
- Tier 2 – The second tier involves a more sophisticated case-by-case application of chemical transport modeling.

The term MERP describes a precursor (NO_x and SO₂) emission rate that is expected to result in a change in ambient secondary PM_{2.5} that is less than a specific air quality concentration threshold. Therefore, if the project's precursor emissions are below the MERPs, the project is not expected to cause or contribute to a violation of the NAAQS due to secondary PM_{2.5} formation. Otherwise, if the project's precursor emissions are above the MERPs, the MERPs can be used to estimate the project's secondary PM_{2.5} impact.

The project's secondary PM_{2.5} impact will be estimated using the most conservative (lowest) illustrative MERP values for the Western U.S. listed in Table 7.1 of the draft MERP guidance. Table 4-2 and Table 4-3 provide the estimated secondary PM_{2.5} impact from the project's NO_x and SO₂ emissions for the worst-case and full load scenarios, respectively. The project's primary PM_{2.5} impacts are expected to be above the SIL; therefore, a PM_{2.5} cumulative impact analysis will be required. The cumulative impact analysis will include the project's secondary PM_{2.5} impact.

Table 4-2. MERP Based Estimated Secondary PM_{2.5} (Worst-Case Load)

Precursor	Precursor Emissions ^A (tpy)	MERP ^B	
		Daily PM (tpy)	Annual PM (tpy)
NO _x	2,049	1,075	3,184
SO ₂	9.5	210	2,289
MERP Critical Threshold (µg/m³)		1.2	0.2
Project % of MERP		195%	65%
MERP Secondary PM_{2.5}		2.34	0.13

^A The listed precursor emissions are the worst-case project emissions.

^B The listed MERP is from EPA's draft *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier I Demonstration Tool for Ozone and PM_{2.5} under the PSD Permitting Program* (EPA 454/R-16-006), Table 7.1 for the western U.S.

Table 4-3. MERP Based Estimated Secondary PM_{2.5} (Full Load)

Precursor	Precursor Emissions ^A (tpy)	MERP ^B	
		Daily PM (tpy)	Annual PM (tpy)
NO _x	863	1,075	3,184
SO ₂	9.5	210	2,289
MERP Critical Threshold (µg/m³)		1.2	0.2
Project % of MERP		85%	28%
MERP Secondary PM_{2.5}		1.02	0.06

^A The listed precursor emissions are the worst-case project emissions.

^B The listed MERP is from EPA's draft *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier I Demonstration Tool for Ozone and PM_{2.5} under the PSD Permitting Program* (EPA 454/R-16-006), Table 7.1 for the western U.S.

4.3. CUMULATIVE IMPACT ANALYSIS

The cumulative impact analysis (stage 2) is required for any pollutant and averaging period, which has a modeled project impact (determined in the project impact analysis) greater than the modeling SIL. The *Guideline* (Section 9.2.3.d) specifies that the cumulative impact analysis should be conducted with the same refined modeling methods used to characterize the project impact and then include the appropriate background

concentrations. The resulting design concentrations should be used to determine whether the project will cause or contribute to a NAAQS or PSD increment violation. This determination should be based on:

1. The appropriate design concentration for each applicable NAAQS (and averaging period); and
2. Whether the source's emissions cause or contribute to a violation at the time and location of any modeled violation (i.e., when and where the predicted design concentration is greater than the NAAQS).

For PSD increments, the cumulative impact analysis should also consider the amount of the air quality increment that has already been consumed by other sources, or, conversely, whether increment has expanded relative to the baseline concentration. Therefore, the applicant should model the existing or permitted nearby increment-consuming and increment-expanding sources.

The cumulative impact analysis will be limited to the areas with significant impact area (area with a predicted ambient impact from the proposed project greater than the respective modeling SIL). A preliminary project impact analysis as described above determined that the areas with significant concentration gradients from the project are expected to occur within 10 km of the project site; the modeling report submitted as part of the application support documentation will include this demonstration.

4.3.1. Ambient Air Quality Modeling Analysis

The NAAQS modeling requires the inclusion of nearby existing sources and ambient background concentrations. Section 3.2.2 describes the emissions inventory of nearby existing sources. Section 3.5 describes the incorporation of the ambient background concentration data.

The objective of this step is to demonstrate that the operation of the proposed units does not cause or contribute to a NAAQS violation at any receptor. If modeled violations are found, then the project's contribution to all modeled violations is compared to the modeling SIL to determine whether the project causes or contributes significantly to the modeled violations. If needed, the AERMOD model output option, MAXDCONT, will be used to perform this contribution analysis. The MAXDCONT option is applicable to the 24-hour $\text{PM}_{2.5}$, 1-hour NO_2 , and 1-hour SO_2 percentile based NAAQS and can be used to determine the project's contribution to the overall high ranked values (e.g., 8th-highest maximum daily 1-hour, 9th-highest maximum daily 1-hour, etc.).

4.3.2. PSD Class II Increment Analysis

The PSD Class II Increment evaluation requires the inclusion of all increment-consuming sources. PSD Class II Increments have not been established for 1-hour SO_2 and 1-hour NO_2 . Table 3-4 lists the baseline dates for the Guam. Nearby sources (as described in Section 3.2.2) will be reviewed to identify any increment-consuming sources that will need to be included in an increments analysis.

The objective of this step is to demonstrate that the operation of the proposed new generating units does not cause or contribute to a PSD Class II Increment violation at any receptor. If modeled violations are found, then the project's contribution to all modeled violations will be compared to the SIL to determine whether the project causes or contributes significantly to any of the modeled violations.

4.4. OZONE ANALYSIS

40 CFR §52.21(c)(50)(i)(f) specifies that projects with a net emissions increase of 100 tpy or more of VOCs shall include an ambient impact analysis including the gathering of ambient air quality data. Table 2-1 shows the project's VOC emissions exceed 100 tpy. Therefore, an analysis of potential effects on ambient O_3 concentrations is required, which includes the collection of preconstruction O_3 monitoring.

4.4.1. Preconstruction Ozone Monitoring Requirements

As disused in Section 3.5, there are no current ambient O₃ data for Guam. Wärtsilä will be submitting a preconstruction monitoring protocol to address the collection of preconstruction O₃ monitoring data.

4.4.2. Ozone Ambient Air Quality Analysis

O₃ is a secondary pollutant; therefore, it cannot be modeled using a traditional point source model such as AERMOD. The *Guideline* (Section 5.3.2) recommends the following two tier approach for assessing single-source O₃ impacts:

- **Tier 1** – The first tier involves use of appropriate and technically credible relationships between emissions and ambient impacts developed from existing modeling studies deemed sufficient for evaluating a project’s impact. EPA is in the process of developing MERPs as a Tier 1 demonstration tool for O₃.
- **Tier 2** – The second tier involves a more sophisticated case-by-case application of chemical transport modeling.

The term MERP describes a precursor emission rate that is expected to result in a change in ambient O₃ that is less than a specific air quality concentration threshold. Therefore, if the project’s precursor emissions are below the MERPs, the project is not expected to cause or contribute to a violation of the NAAQS. Otherwise, if the project’s precursor emissions are above the MERPs, the MERPs can be used to estimate the project’s O₃ impact.

The project’s O₃ impact will be estimated using the most conservative (lowest) illustrative MERP values for the Western U.S. listed in Table 7.1 of the draft MERP guidance. Table 4-4 and Table 4-5 provide the estimated O₃ impact from the project’s NO_x and VOC emissions for the worst-case and full load scenarios, respectively. The analysis showed that project’s VOC and NO_x emissions are above the MERPs. Therefore, the MERPs will used to calculate the project’s O₃ contribution which will be added to the background O₃ for comparison to the NAAQS.

Table 4-4. MERP Based Estimated O₃ Project Impact (Worst-Case Load)

Precursor	Precursor Emissions ^A (tpy)	8-Hour O ₃ MERP ^B (tpy)
VOC	357	1,049
NO _x	2,049	184
MERP Critical Threshold (ppb)		1
Project % of MERP		1148%
Project O ₃ (ppb)		11

^A The listed precursor emissions are the worst-case project emissions listed in Table 2-1.

^B The listed MERP is from EPA's draft *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier I Demonstration Tool for Ozone and PM_{2.5} under the PSD Permitting Program* (EPA 454/R-16-006), Table 7.1 for the western US.

Table 4-5. MERP Based Estimated O₃ Project Impact (Full Load)

Precursor	Precursor Emissions^A (tpy)	8-Hour O₃ MERP^B (tpy)
VOC	345	1,049
NO _x	863	184
MERP Critical Threshold (ppb)		1
Project % of MERP		502%
Project O₃ (ppb)		5

^A The listed precursor emissions are the worst-case project emissions listed in Table 2-1.

^B The listed MERP is from EPA's draft *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier I Demonstration Tool for Ozone and PM_{2.5} under the PSD Permitting Program* (EPA 454/R-16-006), Table 7.1 for the western US.

5. PSD CLASS I AREA ANALYSIS

The 1977 Clean Air Act Amendments give the Federal Land Managers (FLMs) an “affirmative responsibility” to protect the natural and cultural resources of Class I areas from the adverse impacts of air pollution. The FLM responsibilities include the review of air permit applications to ensure that emissions from the proposed source will not cause or contribute to adverse impacts on the AQRVs of a Class I area.

The U.S. EPA has historically requested that Class I Area analyses be completed if the distance between a proposed PSD project and a Class I Area is approximately 300 km or less. There is not a Class 1 Area within 300 km of the proposed site. Therefore, a Class I Area analysis is not required.

6. ADDITIONAL IMPACT ANALYSIS

This section discusses the proposed project's impact on the following:

- Class II Visibility,
- Growth,
- Vegetation and soils,
- Environmental Justice, and
- Additional Federal Regulations.

6.1. CLASS II VISIBILITY

Visibility impact analyses in Class II areas can be required to ensure the project does not adversely impact any scenic/important views. Guam does not contain any integral vistas; therefore, there are no site-specific guidelines for a visibility impact analysis for the area.

6.2. GROWTH

The elements of the growth analysis include a projection of the associated industrial, commercial, and residential growth that will occur in the area of impact due to the proposed project, including the potential impact on ambient air due to this growth. The proposed project is intended to replace retiring GPA generating units and will help accommodate planned normal economic and population growth on the island. Little or no additional industrial, commercial, or residential growth is projected as a result of this proposed project. It is expected that most future employees are already residing on Guam and do not represent a significant change in the population. Therefore, negligible growth-related ambient air impacts are expected.

6.3. VEGETATION AND SOILS IMPACTS

The proposed project is located in an area consisting of Guam cobbly clay loam soil. This soil is very shallow and drains well and formed in sediment overlying porous coralline limestone. The vegetation in the area is not cultivated, and is mainly forest. Typically, 5 to 10 percent of the surface is covered with gravel and cobbles. The surface layer is dark reddish brown cobbly clay loam about 5 centimeters thick. The subsoil is dusky red gravelly clay loam about 15 centimeters thick. Limestone is at a depth of 20 centimeters. The soil is poorly suited for subsistence farming. (SCS, 1988).

The U.S. EPA developed the secondary NAAQS in order to protect certain air quality-related values (i.e., soil and vegetation) that were not sufficiently protected by the primary NAAQS. The secondary NAAQS represent ambient air concentrations below which most types of soil and vegetation are unaffected by criteria pollutants. If the predicted ambient air concentrations are less than the secondary NAAQS, it can be presumed that emissions from the proposed sources will not result in harmful effects to either soil or vegetation. The cumulative impact analysis will address the applicable primary and secondary ambient air quality standards.

To address sensitive vegetation, the screening criteria in EPA's report, "A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals" will be relied upon. The EPA report establishes air pollutant concentrations that are generally viewed to be protective of soils and vegetation having significant commercial or recreational value, including agricultural crops (EPA, 1980a). Table 6-1 compares EPA's criteria pollutant screening concentrations for exposure to ambient air concentrations (screening concentrations) to the NAAQS. In some cases, the screening concentrations are more restrictive than the NAAQS. Maximum modeled

concentrations plus background for all applicable pollutants and averaging periods will be compared to the screening concentrations.

Table 6-1. Comparison of Sensitive Vegetation Screening Concentrations to NAAQS

Minimum Reported Level for Vegetation Sensitivity								NAAQS/ SAAQS (µg/m³)	Most Restrictive Concentration	Source of Most Restrictive Concentration
Pollutant	Averaging Period	Sensitive		Intermediate		Resistant			(µg/m³)	
		(ppmv)	(µg/m³)	(ppmv)	(µg/m³)	(ppmv)	(µg/m³)			
SO ₂	1-hr	0.35	917	--	--	--	--	196	196	NAAQS/SAAQS
	3-hr	0.30	786	0.80	2,096	5.0	13,100	1,300	786	Sensitive Screening
	24-hr	--	--	--	--	--	--	365	365	NAAQS/SAAQS
	Annual	--	--	0.007	18	--	--	80	18	Intermediate Screening
PM ₁₀	24-hr	--	--	--	--	--	--	150	150	NAAQS/SAAQS
	Annual	--	--	--	--	--	--	50	50	NAAQS/SAAQS
PM _{2.5}	24-hr	--	--	--	--	--	--	35	35	NAAQS/SAAQS
	Annual	--	--	--	--	--	--	12	12	NAAQS/SAAQS
NO ₂	1-hr	--	--	--	--	--	--	188	188	NAAQS/SAAQS
	4-hr	2.0	3,760	5.0	9,400	9.0	16,920	--	3,760	Sensitive Screening
	8-hr	2.0	3,760	4.0	7,520	8.0	15,040	--	3,760	Sensitive Screening
	1-month	--	--	0.30	564	--	--	--	564	Intermediate Screening
	Annual	--	--	0.05	94	--	--	70	70	NAAQS/SAAQS
CO	1-hr	--	--	--	--	--	--	10,000	10,000	NAAQS/SAAQS
	8-hr	--	--	--	--	--	--	5,000	5,000	NAAQS/SAAQS
	1-week	1,000	1,144,000	--	--	10,000	11,440,000	--	1,144,000	Sensitive Screening
Fluoride	10-day	--	--	--	0.5	--	--	--	0.50	Intermediate Screening
Beryllium	1-month	--	--	--	0.01	--	--	--	0.01	Intermediate Screening
Lead	3 month	--	--	--	1.5	--	--	0.15	0.15	NAAQS/SAAQS
O ₃	1-hr	0.20	392	0.35	687	0.55	1,079	--	392	Sensitive Screening
	4-hr	0.10	196	0.15	294	0.35	687	--	196	Sensitive Screening
	8-hr	0.06	118	0.15	294	0.30	589	137.3	118	Sensitive Screening

Source : EPA, 1980a, Table 3.1

6.4. ENVIRONMENTAL JUSTICE

Executive Order (EO) 12898 provides for federal agencies to identify and address disproportionately high and adverse effects of their actions on minority, low-income, and tribal populations. The EPA defines Environmental Justice (EJ) to include the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income in environmental decisions that affect them. Consistent with the Agency's commitment to EJ, as part of the permit review process and before issuing a PSD permit, the Regional Office should examine any superficially plausible claim that the facility seeking the PSD permit will disproportionately affect a minority, low-income, or tribal community. The PSD permit application will include a qualitative assessment of the ethnicity and socioeconomic status of the areas that will be affected by emissions from the proposed project, based on the results of the latest available U.S. Census (2010), to determine whether the project could have a disproportionate effect on any of these communities.

6.5. ADDITIONAL FEDERAL REQUIREMENTS

In addition to the CAA requirements, there are requirements in four other statutes that sometimes must be met before a source can begin construction and operation under a PSD permit. This section discusses the proposed project's compliance with the following statutes:

- Coastal Zone Management Act,
- National Historic Preservation Act,
- Magnuson-Stevens Fishery Conservation and Management Act, and
- Endangered Species Act.

6.5.1. Coastal Zone Management Act

The Guam Coastal Management Program (GCMP) was established in 1979 through a cooperative agreement between the National Oceanic and Atmospheric Administration and the Bureau of Planning Office of the Governor and draws its authorities from the Coastal Zone Management Act (CZMA) of 1972. The entire island has been designated a "coastal zone" in the context of the Coastal Zone Management Act. Therefore, all the Territory's land and sea areas and all its land uses related planning and regulatory agencies, programs and laws falls within the concern of the program. Information on the effect of this program on federally owned lands can be found under Federal Consistency.

Wärtsilä will support the determinations and findings required under the CZMA by providing a copy of the PSD permit to NOAA and the Bureau of Planning Office and by providing any additional information requested by the agencies.

6.5.2. National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) requires EPA, prior to the issuance of any license (e.g., permit), to take into account the effects of its undertakings on cultural and historic properties. There are no known historic or cultural properties in the immediate project area. However, if an inadvertent discovery of historic properties occurs, appropriate measures would be taken to preserve and protect these resources and no significant impacts would be expected.

6.5.3. Magnuson-Stevens Fishery Conservation and Management Act

Wärtsilä will send a letter to the U.S. Department of Commerce, National Marine Fisheries Service, Pacific Islands Regional Office (NMFS-PIRO) explaining the project and the associated ambient impacts. Although the proposed project is not expected to have a detrimental impact on any essential fish habitat (EFH), further analysis will be conducted if deemed necessary by the NMFS-PIRO. Wärtsilä will provide EPA a copy of the NMFS-PIRO response.

6.5.4. Endangered Species Act

Wärtsilä will send a letter to the Pacific Islands Fish and Wildlife Office (PIFWO) regarding the proposed project's potential to impact endangered or threatened plants or animals. Although the proposed project is not expected to have a detrimental impact on threatened or endangered species in the project vicinity, further analysis will be conducted if deemed necessary by the PIFWO. Wärtsilä will provide EPA a copy of the PIFWO response.

7. REFERENCES

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40 CFR Part 51 – Appendix W. Guideline on Air Quality Models.

Appendix A: EMISSION CALCULATIONS

Appendix Table A-1
Wärtsilä 18V50DF Pollutant Emission Rate Calculations - ULSD

Parameter	Variable	Units	Wärtsilä 18V50DF		Data Source
			100% Load	50% Load	
			Value	Value	
Performance Data					
Mechanical Output	MO	kW _m	17,550	8,792	Supplied by Wärtsilä via 6/28/2017 email to Trinity
	--	HP	23,517	11,781	Converted from KW _m
Generation	G	kW _e	17,164	8,582	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Heat Rate (LHV)	HR _{LHV}	Btu/kW _e -hr	7,732	8,370	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Heat Input (LHV)	HI _{LHV}	MMBtu/hr	132.7	71.8	HR _{LHV} *G/10 ⁶
Heat Input (HHV)	HI _{HHV}	MMBtu/hr	139.3	75.4	HI _{LHV} *1.05
Fuel Heat Content (LHV)	LHV	Btu/lb	18,362	18,362	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Fuel Flow	FF _{lb/hr}	lb/hr	7,228	3,912	HI _{LHV} /(LHV/10 ⁶)
Exhaust Data					
Exhaust Temp	--	°F	375.8	359.6	Converted from °C
	T _{stack}	°R	835.8	819.6	Converted from °F
	--	°C	191	182	Supplied by Wärtsilä via 6/27/2017 and 6/28/2017 emails to Trinity
	--	K	464.15	455.15	Converted from °C
Universal Gas Constant	R	psia-ft ³ /lbmol-R	10.73	10.73	http://en.wikipedia.org/wiki/Gas_constant
Standard Pressure	P _{std}	psia	14.696	14.696	40 CFR Part 60, Appendix A, Method 5
Standard Temperature	T _{std}	K	293.2	293.2	40 CFR Part 60, Appendix A, Method 5
Exhaust Volumetric Flow (actual)	Q _{m3s}	m ³ /s	44.7	24.4	Supplied by Wärtsilä via 6/27/2017 and 6/28/2017 emails to Trinity
	--	acfh	5,682,836	3,102,040	Converted from m ³ /s
	Q _{acfm}	acfm	94,714	51,701	Converted from acfm
Exhaust H ₂ O Content	%H ₂ O	% by Vol	6.61%	6.48%	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Exhaust O ₂ Content	%O ₂	% by Vol	11.75%	12.00%	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Exhaust CO ₂ Content	%CO ₂	% by Vol	5.67%	5.51%	Supplied by Wärtsilä via 6/28/2017 email to Trinity
Dry Exhaust Volumetric Flow	Q _{dry}	dcf/min	88,453	48,350	Q _{acfm} *(1-%H ₂ O)
%O ₂ Dry Basis	%O _{2-Dry}	%	12.58%	12.83%	%O ₂ /(1-%H ₂ O)
%CO ₂ Dry Basis	%CO _{2-Dry}	%	6.07%	5.89%	%CO ₂ /(1-%H ₂ O)
Dry Exhaust Volumetric Flow (Std)	Q _{dry-std}	dscf/min	55,875	31,147	Q _{dry} *(T _{std} /T _{stack})
Dry Exhaust Volumetric Flow (32 °F)	Q _{dry-32F}	Nm ³ /min	1,474	822	Q _{dry} *(273.15/T _{stack})*.3048 ³
Stack Diameter	D _{ft}	ft	5.25	5.25	Converted from meters
	D _m	m	1.60	1.60	Supplied by Wärtsilä via 6/27/2017 email to Trinity
Stack Area	A _{m2}	m ²	2.01	2.01	(π*D _m ²)/4
Stack Velocity	V _{m/sec}	m/sec	22.23	12.14	Q _{m3s} /A _{m2}
	V _{ft/sec}	ft/sec	72.94	39.81	Converted from m/s

Appendix Table A-1
Wärtsilä 18V50DF Pollutant Emission Rate Calculations - ULSD

Parameter	Variable	Units	Wärtsilä 18V50DF		Data Source
			100% Load	50% Load	
			Value	Value	
Emission Rates					
Max Sulfur	FS _{ppm}	ppm	15	15	Proposed Permit Limit
SO ₂ Emission Rates	--	g/s	2.729E-02	1.477E-02	Converted from lb/hr
	M _{SO2}	lb/hr	0.217	0.117	FF _{lb/hr} *(FS _{ppm} /10 ⁶)*(MW _{SO2} /MW _S) (Mass Balance - 100% conversion of fuel S)
SO ₂ Emission Factors	--	lb/MMBtu	0.00155	0.00155	M _{SO2} /HI _{HHV}
SO ₂ Molecular Weight	MW _{SO2}	lb/lbmol	64.1	64.1	http://www.webelements.com/
S Molecular Weight	MW _S	lb/lbmol	32.1	32.1	http://www.webelements.com/
	Q _{S02}	ft ³ /min	0.0344	0.0183	Calculated using Ideal Gas Law [((M _{SO2} /MW _{SO2})*R*T _{stack})/(P _{std} *60)]
	C _{d-S02}	ppmvd	0.39	0.38	(Q _{SO2} /Q _{dry})*10 ⁶
	--	ppmvd @ 15% O ₂	0.28	0.28	C _{d-S02} *((20.9-15)/(20.9-%O _{2-Dry} *100))
PM/PM ₁₀ /PM _{2.5} Stack Conc.	C _{d15-PM10}	mg/Nm ³ @ 15% O ₂	20	30	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-PM10}	mg/Nm ³	28.2	41.0	C _{d15-PM10} *((20.9-%O _{2-dry} *100)/(20.9-15))
PM/PM ₁₀ /PM _{2.5} Emission Rates	M _{PM-g/s}	g/s	6.927E-01	5.618E-01	C _{d-PM10} /1000*Q _{dry-32F} /60
	M _{PM10-lb/hr}	lb/hr	5.50	4.46	Converted from g/s
PM/PM ₁₀ /PM _{2.5} Emission Factors	--	lb/MMBtu	0.0395	0.0592	M _{PM10-lb/hr} /HI _{HHV}
	--	g/kW _m -hr	0.142	0.23	M _{pm10-g/s} * 3600/MO
	--	g/kW _e -hr	0.145	0.236	M _{pm10-g/s} * 3600/G
NO _x as NO ₂ Stack Conc.	C _{d15-NOX}	ppmvd @ 15% O ₂	35	40	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-NOX}	ppmvd	49.3	54.7	C _{d15-NOX} *((20.9-%O _{2-dry} *100)/(20.9-15))
NO ₂ Molecular Weight	MW _{NO2}	lb/lbmol	46.0	46.0	http://www.webelements.com/
NO _x as NO ₂ Emission Rates	M _{NOX-lb/hr}	lb/hr	19.7	12.2	[(C _{d-NOX} *(1-%H ₂ O))*Q _{acfm} /10 ⁶]*P _{std} *MW _{NO2} /(R*T _{stack})*60
	M _{NOX-g/s}	g/s	2.482	1.537	Converted from lb/hr
NO _x as NO ₂ Emission Factors	--	lb/MMBtu	0.141	0.162	M _{NOX-lb/hr} /HI _{HHV}
	--	g/kW _m -hr	0.509	0.629	M _{NOX-g/s} * 3600/MO
	--	g/kW _e -hr	0.521	0.645	M _{NOX-g/s} * 3600/G

Appendix Table A-1
Wärtsilä 18V50DF Pollutant Emission Rate Calculations - ULSD

Parameter	Variable	Units	Wärtsilä 18V50DF		Data Source
			100% Load	50% Load	
			Value	Value	
Emission Rates (Continued)					
CO Stack Conc.	C _{d15-CO}	ppmvd @ 15% O ₂	20	20	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-CO}	ppmvd	28.2	27.4	C _{d15-CO} *((20.9-%O _{2-dry} *100)/(20.9-15))
CO Molecular Weight	MW _{CO}	lb/lbmol	28.0	28.0	http://www.webelements.com/
CO Emission Rates	M _{CO-lb/hr}	lb/hr	6.87	3.71	[(C _{d-CO} *(1-%H ₂ O))*Q _{acfm} /10 ⁶]*P _{std} *MW _{CO} /(R*T _{stack})*60
	M _{CO-g/s}	g/s	8.656E-01	4.675E-01	Converted from lb/hr
CO Emission Factors	--	lb/MMBtu	0.0493	0.0492	M _{CO-lb/hr} /HI _{HHV}
	--	g/kW _m -hr	0.178	0.191	M _{CO-g/s} * 3600/MO
	--	g/kW _e -hr	0.182	0.196	M _{CO-g/s} * 3600/G
VOC (as CH ₄) Stack Conc.	C _{d15-VOC}	ppmvd @ 15% O ₂	40	40	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-VOC}	ppmvd	56.4	54.7	C _{d15-VOC} *((20.9-%O _{2-dry} *100)/(20.9-15))
VOC (as CH ₄) Molecular Weight	MW _{CH4}	lb/lbmol	16.0	16.0	http://www.webelements.com/
VOC (as CH ₄) Emission Rates	M _{VOC-lb/hr}	lb/hr	7.87	4.25	[(C _{d-VOC} *(1-%H ₂ O))*Q _{acfm} /10 ⁶]*P _{std} *MW _{CH4} /(R*T _{stack})*60
	M _{VOC-g/s}	g/s	9.916E-01	5.355E-01	Converted from lb/hr
VOC (as CH ₄) Emission Factors	--	lb/MMBtu	0.0565	0.0564	M _{VOC-lb/hr} /HI _{HHV}
	--	g/kW _m -hr	0.203	0.219	M _{VOC-g/s} * 3600/MO
	--	g/kW _e -hr	0.208	0.225	M _{VOC-g/s} * 3600/G
NH ₃ Slip	C _{d15-NH3}	ppmvd @ 15% O ₂	10	10	Supplied by Wärtsilä - Doc.ID: DBAD877190
	C _{d-NH3}	ppmvd	14.1	13.7	C _{d15-NH3} *((20.9-%O _{2-Dry} *100)/(20.9-15))
NH ₃ Molecular Weight	MW _{NH3}	lb/lbmol	17.0	17.0	http://www.webelements.com/
NH ₃ Emission Rate	M _{NH3-lb/hr}	lb/hr	2.09	1.13	[(C _{d-NH3} *(1-%H ₂ O))*Q _{acfm} /10 ⁶]*P _{std} *MW _{NH3} /(R*T _{stack})*60
	M _{NH3-g/s}	g/s	2.633E-01	1.424E-01	Converted from lb/hr
Fluorides	EF _{Fl}	lb/MMBtu	2.487E-04	2.487E-04	AP-42, Section 1.3, Table 1.3-11 for No. 6 Fuel Oil
	M _{Fl-lb/hr}	lb/hr	3.464E-02	1.875E-02	EF _{Fl} * HI _{HHV}
	M _{Fl-g/s}	g/s	4.365E-03	2.362E-03	Converted from lb/hr

Appendix Table A-2
Wärtsilä 18V50DF H2SO4 Emission Rate Calculations

Parameter	Variable	Units	Scenario	Data Source
			100% Load	
SO ₂ Emissions Rate	E _{SO2}	lb/hr	0.217	Per Unit Emission Rate
SO ₂ Molecular Weight	MW _{SO2}	lb/lbmol	64.06	http://www.webelements.com/
H ₂ SO ₄ Molecular Weight	MW _{H2SO4}	lb/lbmol	98.08	http://www.webelements.com/
Fuel Impact Factor (combustion SO ₂ oxidation rate)	F1	--	0.055	EPRI, 2012, Table 6.1, worst-case value
H ₂ SO ₄ manufactured from combustion	H ₂ SO _{4-combustion}	lb/hr	0.0182	Based on Equation 6.4 (EPRI, 2012)
CO catalyst SO ₂ oxidation rate	S3	--	0.35	EPRI, 2012, Page 6-5, average value
H ₂ SO ₄ manufactured from the CO catalyst	H ₂ SO _{4-CO_catalyst}	lb/hr	0.1161	Based on Equation 6.5 (EPRI, 2012)
SCR catalyst SO ₂ oxidation rate	S2	--	0.03	EPRI, 2012, Page 6-5, maximum value
H ₂ SO ₄ manufactured from the SCR catalyst	H ₂ SO _{4-SCR_catalyst}	lb/hr	0.0065	Based on Equation 6.6 (EPRI, 2012)
Total H ₂ SO ₄ manufactured (CSP Application Emission Rate)	EM _{H2SO4}	lb/hr	0.141	H ₂ SO _{4-combustion} + H ₂ SO _{4-CO_catalyst} + H ₂ SO _{4-SCR_catalyst}
	--	tpy	0.618	Converted from lb/hr
	EM _{H2SO4-lbmole}	lbmol/hr	0.0014	EM _{H2SO4} / MW _{H2SO4}
100% of Fuel Sulfur Converted to H ₂ SO ₄	--	lb/hr	0.332	Mass Balance
% of Fuel Sulfur Converted to H ₂ SO ₄	--	--	42.5%	Mass Balance
NH ₃ Slip	E _{NH3}	lb/hr	2.09	Per Unit Emission Rate
NH ₃ Molecular Weight	MW _{NH3}	lb/lbmol	17.03	http://www.webelements.com/
	E _{NH3-lbmole}	lbmol/hr	0.123	E _{NH3} / MW _{NH3}
Net H ₂ SO ₄ Emissions (NH ₃ exceeds H ₂ SO ₄ emissions, therefore, 100% of the H ₂ SO ₄ could be converted to ammonium sulfate)	E _{H2SO4-lbmole}	lbmol/hr	-0.121	EM _{H2SO4-lbmole} - E _{NH3-lbmole} - The residual NH ₃ from the SCR (NH ₃ Slip) can react with the H ₂ SO ₄ to form ammonium sulfate (Page 4-12, EPRI, 2012)

Source: *Estimating Total Sulfuric Acid Emissions from Stationary Power Plants*, Electrical Power Research Institute (EPRI) Product ID: 1023790, dated March 2012 (<http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=00000000001023790>). The CSP application emission rate calculations above are based on: (a) worst-case combustion and SCR catalyst oxidation rates, (b) an average CO catalyst oxidation rate, and (c) do not account for the potential reduction in H₂SO₄ emissions due to possible reactions with NH₃ slip.

Appendix Table A-3
Wärtsilä 18V50DF Startup Emission Rates - ULSD

Cold Start¹							
Time (min.)	Operating Mode	Emissions (lb)					
		SO₂	NO_x	CO	PM	PM₁₀/PM_{2.5}	VOC
1 - 30	Startup	0.1083	249.90	4.40	4.40	4.40	6.40
31 - 60	Normal (Worst-case load)	0.1083	9.85	3.44	2.75	2.75	3.94
Total	(lb/hr)	0.2166	259.8	7.84	7.15	7.15	10.34
	(g/s)	2.729E-02	32.73	0.988	9.009E-01	9.009E-01	1.303

¹ A cold catalyst start is when the temperature of the catalyst is close to the ambient temperature.

Warm Start²							
Time (min.)	Operating Mode	Emissions (lb)					
		SO₂	NO_x	CO	PM	PM₁₀/PM_{2.5}	VOC
1 - 30	Startup	0.1083	220.40	2.40	4.40	4.40	5.70
31 - 60	Normal (Worst-case load)	0.1083	9.85	3.44	2.75	2.75	3.94
Total	(lb/hr)	0.2166	230.3	5.84	7.15	7.15	9.64
	(g/s)	2.729E-02	29.01	0.7358	9.009E-01	9.009E-01	1.215

² A warm catalyst start is when the unit is started within 12 hours of shutdown.

Hot Start³							
Time (min.)	Operating Mode	Emissions (lb)					
		SO₂	NO_x	CO	PM	PM₁₀/PM_{2.5}	VOC
1 - 30	Startup	0.1083	209.40	2.40	4.40	4.40	6.40
31 - 60	Normal (Worst-case load)	0.1083	9.85	3.44	2.75	2.75	3.94
Total	(lb/hr)	0.2166	219.3	5.84	7.15	7.15	10.34
	(g/s)	2.729E-02	27.63	0.7358	9.009E-01	9.009E-01	1.303

³ A hot catalyst start is when the unit is started within 6 hours of shutdown and the catalyst temperature is above 100°F.

Per Unit Annual Startup Emissions							
Startup Scenario	Startups Per Day	Emissions (tpy)					
		SO₂	NO_x	CO	PM	PM₁₀/PM_{2.5}	VOC
Cold	1	0.040	47.4	1.43	1.30	1.30	1.89
Warm	1	0.040	42.0	1.07	1.30	1.30	1.76
Hot	1	0.040	40.0	1.07	1.30	1.30	1.89
Total	3	0.119	129.4	3.56	3.91	3.91	5.53

Appendix Table A-4
Wärtsilä 18V50DF GHG Emission Rate Calculations - ULSD

Unit	Heat Input (MMBtu/hr)	Load (MW)	Operating Hours (hrs/yr)	Annual Heat Input (MMBtu/yr)	GHG Pollutant ¹	Emission Factor ² (kg/MMBtu)	Max. Hourly Emissions (kg/hr)	Annual Emissions (metric tpy)	Global Warming Potential ³	Per Unit Total GHG Emissions			Number of Units	Total GHG Emissions		
										CO ₂ e				CO ₂ e		
										(lb/hr)	(metric tpy)	(tpy)		(lb/hr)	(metric tpy)	(tpy)
100% (Base) Load																
Wärtsilä 18V50DF	139.3	17.2	8,760	1,220,268	CO ₂	73.96	10,303	90,251	1	22,713.4	90,251.0	99,484.7	10	227,134.1	902,510.2	994,847.2
					N ₂ O	6.0E-04	8.36E-02	0.732	298	54.9	218.2	240.5		549.1	2,181.8	2,405.1
					CH ₄	3.0E-03	4.18E-01	3.66	25	23.0	91.5	100.9		230.3	915.2	1,008.8
Total CO ₂ e =										22,791.3	90,560.7	99,826.1		227,913.5	905,607.3	998,261.1
50% of Base Load																
Wärtsilä 18V50DF	75.4	8.6	8,760	660,504	CO ₂	73.96	5,577	48,851	1	12,294.3	48,850.9	53,848.9	10	122,942.6	488,508.8	538,488.7
					N ₂ O	6.0E-04	4.52E-02	0.396	298	29.7	118.1	130.2		297.2	1,181.0	1,301.8
					CH ₄	3.0E-03	2.26E-01	1.98	25	12.5	49.5	54.6		124.7	495.4	546.1
Total CO ₂ e =										12,336.5	49,018.5	54,033.7		123,364.5	490,185.1	540,336.6

¹ Greenhouse Gas (GHG) pollutants from the Mandatory Greenhouse Gas Reporting rule (40 CFR §98.32).

² Emission factors from the Mandatory Greenhouse Gas Reporting rule (40 CFR Part 98 Subpart C, Tables C-1 and C-2).

³ Global Warming Potentials from the Mandatory Greenhouse Gas Reporting rule (40 CFR Part 98 Subpart A, Table A-1).

Appendix B: NO₂ MODELING TIER 3 JUSTIFICATION

AERMOD (starting with version 16216r) contains the OLM and PVMRM modules as regulatory Tier 3 options for modeling the conversion of NO to NO₂. The inclusion of these elements into AERMOD as regulatory options removes the alternative model approval requirement for OLM and PVMRM. However, the applicant must demonstrate that OLM and PVMRM are applicable on a theoretical basis to the project. The following sections describe how OLM and PVMRM are appropriate for modeling NO₂ concentrations for this project. The Tier 3 analysis will be performed only if necessary.

OZONE LIMITING METHOD TECHNICAL DISCUSSION

The OLM is a detailed screening methodology that accounts for the direct emissions of NO₂ and the conversion of NO into NO₂ in the presence of O₃ once the plume leaves the stack.

Direct NO₂ emissions result from the thermal reaction due to the relatively high exhaust temperatures of the combustion source. After the exhaust exits the stack, the remaining NO reacts with O₃ to form NO₂ and molecular oxygen (O₂) through O₃ titration:



The OLM assumes that at any given receptor location, the amount of NO converted to NO₂ by this reaction is proportional to the O₃ concentration. If the O₃ concentration is less than the NO concentration, the amount of NO₂ formed by this reaction is limited. This condition is commonly referred to as “O₃ limited.” If the O₃ concentration is greater than or equal to the NO concentration, all NO is converted to NO₂ (Cole and Summerhays, 1979).

PLUME VOLUME MOLAR RATIO METHOD TECHNICAL DISCUSSION

The PVMRM is a detailed screening methodology based on O₃ titration (see equation 1 above) that determines the conversion rate of NO to NO₂ as follows. PVMRM:

- Determines the volume of the plume at the receptor. The plume volume calculations use the relative dispersion coefficients that employ the meteorological parameters available in AERMOD and are consistent with the AERMOD’s treatment of dispersion (EPA, 2016).
- Determines the number of moles of NO contained within the plume.
- Determines the number of moles of O₃ in the plume by multiplying the ambient O₃ concentration by the plume volume.
- Calculates the ratio of the number of O₃ moles to the number of NO moles in the plume.
- Calculates the amount of NO converted to NO₂ at the receptor. The modeled NO₂ concentration equals the modeled NO concentration multiplied by the ratio above if the ratio is less than 1 (O₃ limited). Otherwise, 100% of the NO is converted to NO₂.
- Limits the total NO₂ concentration to no more than a user-specified equilibrium ratio of the total NO_x at the receptor. We will use the default equilibrium ratio of 0.90 in the modeling.

OLM AND PVMRM ARE APPLICABLE TO THE PROBLEM ON A THEORETICAL BASIS

This section demonstrates that the O₃ titration mechanism is appropriate and that other mechanisms do not contribute significantly to the overall process of chemical transformation of NO to NO₂ for this study.

In general, the O₃ titration mechanism is responsible for most of the NO to NO₂ conversion (Hanrahan, 1999a). However, there may be site-specific conditions where other mechanisms contribute significantly to the conversion of NO to NO₂. Cole and Summerhays (1979) present a complete discussion of the O₃ titration mechanism. They note two important yet counter-balancing limitations for the O₃ titration mechanism:

- 1) The conversion of NO to NO₂ by peroxy radicals is neglected, which may underestimate the amount of NO₂ produced when the process is O₃ limited, and
- 2) The method ignores photo-dissociation of NO₂ back into NO caused by UV radiation, which may result in an overestimate of converted NO₂ during daylight periods¹⁴.

The conversion of NO to NO₂ by peroxy radicals (RO₂) requires an ample supply of reactive VOCs (represented by RH). The VOCs (RH) react with the hydroxyl radical (OH) to form organic radicals (R) which eventually form RO₂ (CGER, 1991):



These peroxy radicals (RO₂) then react with available NO to form NO₂.

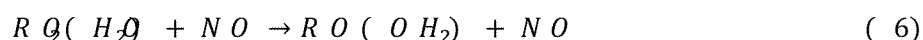
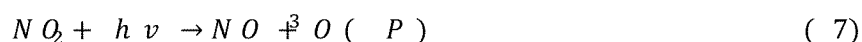


Photo-dissociation of NO₂ back into NO operates in a similar manner. NO₂ can be destroyed by sunlight resulting in NO and a ground state oxygen atom (O(³P)). The ground state oxygen atom then combines with an oxygen molecule to regenerate the O₃ molecule once again.



The O₃ regeneration rate depends on the NO₂ photolysis rate (which is a function of the solar zenith angle) and other factors (CGER, 1991).

Another NO₂ reduction pathway that may be important in Guam involves the photochemical reduction of NO₂ by OH. OH is considered a “detergent of the atmosphere” because it is responsible for the removal of many atmospheric trace gases, including CO, CH₄ and VOCs. The reaction of OH with trace gases is the primary sink mechanism for OH. In areas with a low VOC/NO_x ratio, the NO₂ competes with VOCs for the OH radical which leads to slower peroxy radical production. The slower peroxy radical production means smaller quantities of NO are oxidized to NO₂.

Regions with VOC/NO_x ratios around 8 or higher typically have an ample supply of peroxy radicals (RO₂, HO₂) (CGER, 1991). In these regions, NO can react with peroxy radicals to form NO₂ (see equation 6). On the other hand, in regions with relatively low VOC/NO_x ratios, the radicals used for oxidation of VOCs are instead scavenged by the NO_x, which slows the production of the peroxy radicals and reduces NO_x concentrations (CGER, 1991). The lower concentration of VOCs also results in a lower possible number of peroxy radicals, which lowers the potential rate of NO to NO₂ conversion.

Therefore, the NO and peroxy radical reaction could be an important mechanism for NO₂ formation when all three of the following conditions exist:

1. The region has an ample supply of OH radicals (Andreae and Crutzen, 1997; CGER, 1991),
2. Relatively high VOC concentrations are present (Cole and Summerhays, 1979; CGER, 1991), and
3. The VOC/NO_x ratio is around 8 or higher (CGER, 1991).

¹⁴ The model output, without any post-model adjustments to account for additional conversion mechanisms, was used in the study.

Condition 3 is not expected in Guam. Therefore, the oxidation of NO by O₃ is the primary pathway for NO₂ formation in the atmosphere in Guam. Thus, the model (OLM and PVMRM) is applicable to the problem on a theoretical basis for this site.

PROJECT AREA IS OZONE LIMITED

There are no active ambient air quality monitors on Guam. The closest EPA air quality monitors are located in Hawaii. Since both Guam and Hawaii are remote islands in the Pacific Ocean with limited industrial sources, the majority of O₃ in both locations is expected to be from long range transport. DOH's Kapolei AQM station is the only DOH AQM station that collects both O₃ and NO₂. DOH's Kapolei AQM is located adjacent to the main industrial area on the Island of O'ahu. A review of the Kapolei monitoring data available from EPA's AQS Data Mart¹⁵ found that concurrent hourly NO, NO₂, and O₃ data are available from January 1, 2011 to July 19, 2013.

Appendix Table B-1 and Appendix Figure B-1 show the hourly average monitored NO₂/NO_x ratio and O₃ decreases as the hourly average NO_x concentration increases; which is consistent with O₃ limited conditions.

CONCLUSION

The use of OLM and PVMRM is limited to areas in which the primary NO to NO₂ conversion is the O₃ titration mechanism and are O₃ limited. The project area meets both of those conditions. Thus, OLM and PVMRM are appropriate and may be used for modeling the NO₂ concentrations for this project.

Appendix Table B-1. Measured Hourly Average NO₂/NO_x and O₃ at DOH's Kapolei AQM Station

NO _x (ppb)	Number of Hourly Observations ^{A,B}	Hourly Average NO ₂ /NO _x Ratio	Hourly Average O ₃ (ppb)
> 0 - ≤ 20	13,693	0.6303	25.6
> 20 - ≤ 40	304	0.4966	14.0
> 40 - ≤ 60	64	0.3728	11.2
> 60 - ≤ 80	8	0.3442	10.5
> 80	1	0.3138	3.0

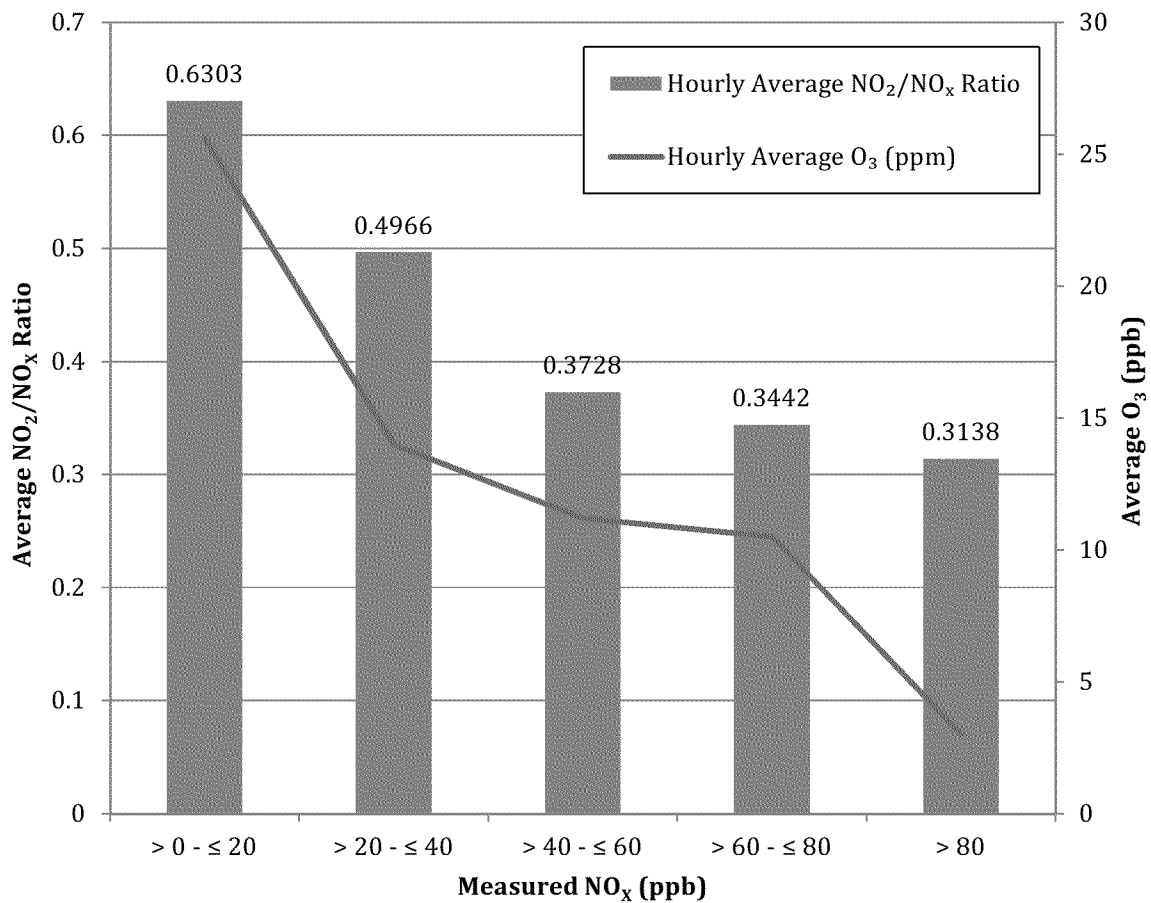
Source: EPA's AQS Data Mart database (<https://aqs.epa.gov/api>)

^A Limited to observations with NO, NO₂, and O₃ > 0 ppb.

^B Data collected between January 1, 2011 - July 19, 2013. Data from hours 07/14/2012 hour 4, 07/15/2012 hour 4, and 07/16/2012 hour 4 were excluded due to irregularities with the reported NO_x and NO concentrations.

¹⁵ <https://aqs.epa.gov/api>

Appendix Figure B-1. Measured Hourly Average NO_2/NO_x and O_3 at DOH's Kapolei AQM Station



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